# MARINE MAMMAL MONITORING AND MITIGATION DURING OPEN WATER SEISMIC EXPLORATION BY CONOCOPHILLIPS ALASKA, INC. IN THE CHUKCHI SEA, JULY–OCTOBER 2006


Alaska Research Associates, Inc.
1101 E. 76th Ave. Suite B, Anchorage, AK 99518

**LGL Ltd., environmental research associates**
P.O. Box 280, 22 Fisher Street, King City, Ont. L7B 1A6, Canada

and

**JASCO Research Ltd.**
4464 Markham Street, Suite 2101, Victoria, BC. V8Z 7X8

for

ConocoPhillips
700 G St., Anchorage, AK, 99501

and

**National Marine Fisheries Service, Office of Protected Resources**
1315 East-West Hwy, Silver Spring, MD 20910-3282



LGL Report P903-2

January 2007

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by

Darren Ireland[a], Robert Rodrigues[a], David Hannay[c], Meaghan Jankowski[b],
Andrea Hunter[b], Heather Patterson[b], Beth Haley[a],
and Dale W. Funk[a]

[a] **LGL Alaska Research Associates, Inc.**
1101 East 76th Ave., Suite B, Anchorage, AK 99518, U.S.A.

[b] **LGL Limited, environmental research associates**
P.O. Box 280, 22 Fisher Street, King City, Ont. L7B 1A6, Canada

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**Suggested format for citation:**

Ireland, D., R. Rodrigues, D. Hannay, M. Jankowski, A. Hunter, H. Patterson, B. Haley, and D. W. Funk. 2007. Marine mammal monitoring and mitigation during open water seismic exploration by ConocoPhillips Alaska Inc. in the Chukchi Sea, July–October 2006: 90-day report. LGL Draft Rep. P903-1. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, LGL Ltd., King City, Ont., and JASCO Research Ltd., Victoria, BC, for ConocoPhillips Alaska, Inc., Anchorage, AK, and Nat. Mar. Fish. Serv., Silver Spring, MD. 116 p.

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# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ~ | approximately |
| AASM | Airgun Array Source Model |
| ADCP™ | Acoustic Doppler Current Profiler |
| AEWC | Alaska Eskimo Whaling Commission |
| ASL | above sea level |
| Bf | Beaufort Wind Force |
| BO | Biological Opinion |
| BOE | barrels of oil equivalent |
| CAA | Conflict Avoidance Agreement |
| CFR | (U.S.) Code of Federal Regulations |
| CITES | Convention on International Trade in Endangered Species |
| cm | centimeter |
| CPA | Closest (Observed) Point of Approach |
| CTD | conductivity, temperature, depth |
| dB | decibel |
| EA | Environmental Assessment |
| EFD | Energy Flux Density |
| ESA | (U.S.) Endangered Species Act |
| $f(0)$ | sighting probability density at zero perpendicular distance from survey track; equivalently, 1/(effective strip width) |
| ft | feet |
| G. gun | variant of an airgun, manufactured by Sodera, a French company owned by Sercel |
| GI | Generator Injector |
| GIS | Geographic Information System |
| GMT | Greenwich Mean Time |
| GPS | Global Positioning System |
| $g(0)$ | probability of seeing a group located directly on a survey line |
| h | hours |
| hp | horse power |
| Hz | Hertz (cycles per second) |
| IHA | Incidental Harassment Authorization (under U.S. MMPA) |
| $in^3$ | cubic inches |
| IUCN | International Union for the Conservation of Nature |
| kHz | kilohertz |
| km | kilometer |
| $km^2$ | square kilometers |
| km/h | kilometers per hour |
| kt | knots |
| L-DEO | Lamont-Doherty Earth Observatory (of Columbia University) |
| LoA | Letter of Authorization |
| µPa | micro Pascal |
| m | meters |
| MBB | Multibeam Bathymetric (sonar) |

| | |
|---|---|
| MCS | Multi-Channel Seismic |
| min | minutes |
| MM | million |
| MMO | Marine Mammal Observer |
| MMPA | (U.S.) Marine Mammal Protection Act |
| MONM | Marine Operations Noise Model |
| *n* | sample size |
| n.mi. | nautical miles |
| NMFS | (U.S.) National Marine Fisheries Service |
| No. | number |
| NSF | (U.S.) National Science Foundation |
| NTCL | Northern Transportation Co., Ltd. |
| OBH | ocean bottom hydrophone |
| PAM | Passive Acoustic Monitoring |
| PD | Power down of the airgun array to one airgun (in this study, from an output of 3390 $in^3$ to 105 $in^3$ ) |
| PE | Parabolic Equation |
| pk-pk | peak-to-peak |
| RAM | Range-dependent Acoustic Model |
| re | in reference to |
| rms | root-mean-square: an average, in the present context over the duration of a sound pulse |
| s | seconds |
| SD | Shut Down of airguns not associated with mitigation |
| s.d. | standard deviation |
| SCUBA | self-contained underwater breathing apparatus |
| SEL | Sound Exposure Level: a measure of energy content, in dB re 1 $\mu Pa^2 \cdot s$ |
| SIS | sea ice seismometers |
| SOI | Shell Offshore, Inc. |
| SPL | Sound Pressure Level; the SPL for a seismic pulse is equivalent to its rms level |
| SZ | Shut Down of all airguns because of a marine mammal sighting near or within the safety radius |
| TTS | Temporary Threshold Shift |
| UNEP | United Nations Environmental Programme |
| USCG | United States Coast Guard |
| USCGC | United States Coast Guard cutter |
| "Useable" | Visual effort or sightings made under the following observation conditions: daylight periods within the Chukchi Sea, ***excluding*** periods 3 min to 1 h (pinnipeds) or 2 h (for cetaceans) after airguns were turned off (post-seismic), periods when ship speed was <3.7 km/h (2 kt), and periods with seriously impaired sightability. The following conditions were defined as involving seriously impaired sightability: all nighttime periods, and daytime periods with one or more of the following: visibility <3.5 km, Bf >5 (Bf >2 for porpoises), or >60º of severe glare between 90º left and 90º right of the bow. Sightings of marine mammals hauled out on the ice in the Chukchi Sea were considered "useable" for analyses. Sightings of cetaceans from the chase vessels were considered "unuseable" for analyses. |

# EXECUTIVE SUMMARY

***Background and Introduction (Chapter 1).—***ConocoPhillips Alaska, Inc. (CPAI) collected marine seismic data in the Chukchi Sea during the summer of 2006 in support of potential future oil and gas leasing and development. Deep seismic acquisition for CPAI was conducted in the Chukchi Sea by WesternGeco using the source vessel M/V *Western Patriot*.

Marine seismic surveys emit sounds into the water that could affect marine mammal behavior and distribution, or perhaps cause temporary or permanent reduction in hearing sensitivity. These effects could constitute "taking" under the provisions of the U.S. Marine Mammal Protection Act (MMPA) and the U.S. Endangered Species Act (ESA). The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) share jurisdiction over the marine mammal species that were likely to be encountered during the project. Cetaceans and most pinnipeds are managed by NMFS; Pacific walruses and polar bears are managed by USFWS.

CPAI's seismic surveys in the Chukchi Sea were conducted under the jurisdiction of Incidental Harassment Authorizations (IHAs) issued by NMFS and USFWS. These IHAs were granted to CPAI on the assumptions that

- the numbers of whales and seals potentially harassed (as defined by NMFS criteria) during seismic operations would be "small",
- the effects of such harassment on marine mammal populations would be negligible,
- no marine mammals would be seriously injured or killed,
- there would be no unmitigated adverse effects on the availability of marine mammals for subsistence hunting in Alaska, and
- the agreed upon monitoring and mitigation measures would be implemented.

Under current NMFS guidelines, "safety radii" for marine mammals around airgun arrays are defined as the distances within which the received pulse levels are ≥180 dB re 1 $\mu Pa_{rms}$ for cetaceans and ≥190 dB re 1 $\mu Pa_{rms}$ for pinnipeds. Those safety radii are based on an assumption that seismic pulses above these levels *might* injure these mammals or impair their hearing abilities. The IHA issued by NMFS required that shipboard personnel monitor the designated ≥180 and ≥190 dB "safety radii" and initiate a power down or shut down of the airguns when marine mammals were seen within or about to enter those zones. The IHA also required monitoring of the distance within which received sound levels are ≥160 dB re 1 $\mu Pa_{rms}$, the sound level at which NMFS believes that behavioral disturbances occur. This larger area was monitored by the chase boat that accompanied the seismic vessel. Power down of the seismic airgun array was required if ≥12 non-migratory bowhead or gray whales were detected ahead of, or perpendicular to, the seismic vessel track.

The primary objectives of the overall monitoring program were as follows:

1. provide real-time sighting data needed to implement the mitigation requirements;
2. estimate numbers of marine mammals potentially exposed to strong seismic pulses; and
3. determine the reactions (if any) of marine mammals potentially exposed to seismic sound impulses.

This 90-day report describes the methods and results for the monitoring work specifically required to meet the above primary objectives.

***Seismic Surveys Described (Chapter 2).—***The *Western Patriot* was the seismic source vessel during CPAI's activities in the Chukchi Sea in 2006. During most survey activities, the Western Patriot was accompanied by one of two chase vessels, the *Torsvik* or the *Gulf Provider*. The *Western Patriot* left Dutch Harbor for the study area on 15 July and began collecting seismic data in the Chukchi Sea on 24 July. The airguns and streamers were retrieved on 6 Oct. The Western Patriot departed southward from the project area and left the Chukchi Sea on 14 Oct., arriving back in Dutch Harbor on 18 Oct. The geographic region where the deep seismic survey occurred was located in the Chukchi Sea MMS OCS Program Area designated as Chukchi Sea Sale 193 (1989) and in the proposed 2002–2007 Chukchi Sea Program Area.

CPAI used WesternGeco's double array of Bolt airguns for its 3–D seismic survey operations in the Chukchi Sea. Two 3390 $in^3$arrays that were fired alternately were towed side by side, 242 m behind the *Western Patriot*. For each airgun shot, one 3390 $in^3$ source array would fire. Each array was composed of 2 identically-tuned Bolt airgun sub-arrays, each with 8 airguns and a total volume of 1695 $in^3$. Individual airguns operated at an air pressure of 2000 psi (provided by air compressors aboard the *Western Patriot)*. The receiving system included 6 hydrophone streamers 4000 m in length, which recorded reflected sound energy. Seismic pulses were emitted at intervals of ~50 m (~20-25 s) while the *Western Patriot* traveled at a speed of 4–5 knots (8.3–9.3 km/h).

***Acoustic Modeling and Measurements (Chapter 3)***.—Prior to conducting seismic survey activities, CPAI contracted JASCO Research Ltd. to provide an acoustic model to estimate the extent of ensonification from the proposed airgun arrays: a one string array of 8 airguns (1695 $in^3$) and a two string array of 16 airguns (3390 $in^3$). Their model takes account of the specific configuration of the airgun array. It also allows for the effects of the anticipated environmental conditions, including water properties, bathymetry, and bottom conditions on the propagation of the sound through the water and bottom.

The acoustic modeling predicted distances at which the received sound level, on an rms basis, would be 190, 180, 170 and 160 dB re 1 μPa rms. These original ("flat-weighted") calculations provided the safety radii applied during initial airgun operations, before field measurements were available. Additionally, sensitivity weighting (*M*-weighting) was applied to modeled underwater sound levels to weight the sound at various frequencies in accordance with the hearing characteristics of different marine mammal groups, i.e., baleen whales, toothed whales, and pinnipeds.

At the start of operations in the Chukchi Sea, JASCO conducted field measurements of the underwater sound levels produced by the 3390 $in^3$ airgun array that was to be used for the seismic surveys. Underwater sound level measurements were obtained from three autonomous Ocean Bottom Hydrophone (OBH) recorder systems deployed from the support vessel *Torsvik* on 24 Jul. 2006 in the Chukchi Sea near the proposed seismic survey area. After deployment of the OBHs, the *Western Patriot* proceeded along a planned survey track starting at 40 km from the OBH systems. The survey vessel fired its airguns at intervals of ~10 s during the source verification measurement period and completed its survey track on 25 Jul. 2006 after approximately 12 h. The OBH's were retrieved and the acoustic data were downloaded and analyzed to determine sound exposure level versus range for the full 3390 $in^3$ array. Safety radii based on these measurements were calculated and presented to CPAI within 72 h, to be used by marine mammal observers on the seismic vessel during data acquisition.

A comparison of the final empirical vs. modeled SPL values showed that the empirical distances exceeded modeled distances (by 1.1–2.5 x). This was attributed mainly to differing bottom types between the location at which pre-season model estimates were performed and at the location of the source verification tests. For the 3390 $in^3$ array, the final empirical values in the endfire aspect were 514 m for 190 dB, 1112 m for 180 dB, 2394 m for 170 dB, and 5086 m for 160 dB. The broadside aspect had measured distances of 517 m for 190 dB, 1628 m for 180 dB, 4689 m for 170 dB, and 11,431 m for 160 dB. The measured broadside sound pressure levels at all distances (160–190 dB) were greater than the endfire range for the 3390 $in^3$ array. The distances of the broadside sound pressure levels were used to estimate the number of individual animal exposures to different sound levels, as a conservative measure.

***Monitoring and Mitigation Methods (Chapter 4).***—The main purposes of the vessel-based monitoring program were to ensure that the provisions of the IHAs issued to CPAI by NMFS and USFWS were satisfied, effects on marine mammals were minimized, and residual effects on animals were documented.

During CPAI seismic surveys in the Chukchi Sea in 2006, at least one MMO onboard the source vessel maintained a visual watch for marine mammals during all daylight hours while seismic surveys were underway. During the surveys, two visual observers were on duty for 31% of the time watches were conducted on the *Western Patriot*. Observers focused their search effort forward and to the side of the vessel, but also searched aft of the vessel. Watches were conducted with the naked eye, Fujinon 7 × 50 reticle binoculars, and Cannon 18 × 60 binoculars. MMOs instructed seismic operators to power down or shut down the airguns if marine mammals were sighted within, or about to enter, the appropriate safety radii.

In general, vessel-based data were categorized as "seismic", "post-seismic", or "non-seismic". "Seismic" included all data collected from the source vessel (*Western Patriot*) while the airguns were operating. Data collected during "post-seismic" periods from 3 min to 1 h (for pinnipeds) or 2 h (for cetaceans) after cessation of seismic activity were considered either "recently exposed" (3–30 min) or "potentially exposed" (30 min to 1 or 2 h) to seismic sound levels, and were excluded from analyses. "Non-seismic" included all data obtained before the airguns were activated (pre-seismic) or after the "post-seismic" period.

Marine mammal sightings during the "seismic" and "non-seismic" periods were used to calculate sighting rates. Sighting rates were then used to calculate the corresponding densities of marine mammals near the survey and chase vessels during seismic and non-seismic periods. These densities were used to estimate the numbers of marine mammals that may have been exposed to various levels of ensonification to determine the estimated take by harassment.

***Monitoring and Mitigation Results (Chapter 5)***.—Marine mammal observers aboard the *Western Patriot* conducted 17,862 km and 1,965 h of visual observation and MMOs aboard the chase vessels conducted 12,544 km and 1111 h of visual observation, together documenting 971 sightings of 1103 pinnipeds and 63 sightings of 86 cetaceans (Table ES.1). There were numerous sightings of supply and chase vessels within 5 km of each of the observation vessels.

TABLE ES.1. Summary of *Western Patriot* and chase vessel operations, observer monitoring effort, and marine mammal sightings during CPAI marine geophysical surveys in the Chukchi Sea 2006.

| | Non-Seismic | | | Seismic | | | |
|---|---|---|---|---|---|---|---|
| | Useable[a] | Other | Post-seismic | Useable[a] | Other | Total Useable[a] | Total |
| ***A. Patriot*** | | | | | | | |
| **Total observer effort in h** | 115 | 102 | 10 | 523 | 1215 | 638 | **1965** |
| **Total observer effort in km** | 890 | 854 | 90 | 4800 | 11228 | 5690 | **17862** |
| **Marine mammal sightings (indv.)** | | | | | | | |
| ***Cetaceans*** | 8(10) | 3(3) | 0 | 2(2) | 9(10) | 10(12) | **22(25)** |
| ***Pinnipeds in water*** | 3(3) | 1(1) | 1 (1) | 81(91) | 56(62) | 84(94) | **142(158)** |
| *Pacific Walrus* | 2(2) | 0 | 0 | 11(16) | 10(14) | 13(18) | **23(32)** |
| ***Unknown*** | 0 | 0 | 0 | 1(1) | 3(3) | 1(1) | **4(4)** |
| **Power downs/shut downs** | | | | | | | **44/1** |
| **B. Chase vessel** | | | | | | | |
| **Total observer effort in h** | 541 | 570 | *N/A* | *N/A* | *N/A* | 541 | **1111** |
| **Total observer effort in km** | 6482 | 6062 | *N/A* | *N/A* | *N/A* | 6482 | **12544** |
| **Marine mammal sightings (indv.)** | | | | | | | |
| ***Cetaceans*** | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* |
| ***Pinnipeds in water*** | 652(754) | 175(188) | *N/A* | *N/A* | *N/A* | 652(754) | **827(942)** |
| *Pacific Walrus* | 45(79) | 17(23) | *N/A* | *N/A* | *N/A* | 45(79) | **62(102)** |
| ***Pinnipeds on ice*** | | | | | | | |
| *Pacific Walrus* | 2(3) | 0 | *N/A* | *N/A* | *N/A* | 2(3) | **2(3)** |

Note: N/A means not applicable.

[a] See *Acronyms and Abbreviations for description of "useable" sightings.*

Based on the estimated densities of marine mammals in the Chukchi Sea during this project, about 12,403 different individual seals, 351 Pacific walruses, and 170 cetaceans would be expected to occur within the areas ensonified to ≥160 dB re 1 $\mu Pa_{rms}$ at some time during the field season. Corresponding estimates in CPAI's IHA applications for seals, walruses and cetaceans were 12,616, 3652 and 169, respectively.

# 1. BACKGROUND AND INTRODUCTION

ConocoPhillips Alaska, Inc. (CPAI) collected offshore seismic data in the Chukchi Sea during summer 2006 in support of potential future oil and gas leasing and development. Deep seismic acquisition was conducted in the Chukchi Sea by WesternGeco using the M/V *Western Patriot*, a seismic vessel that towed an airgun array as well as hydrophone streamers to record reflected seismic data.

Marine seismic surveys emit sound energy into the water (Greene and Richardson 1988; Tolstoy et al. 2004a,b), and have the potential to affect marine mammals, given the reported auditory and behavioral sensitivity of many such species to underwater sounds (Richardson et al. 1995; Gordon et al. 2004). The effects could consist of behavioral or distributional changes, and perhaps (for animals close to the sound source) temporary or permanent reduction in hearing sensitivity. Either behavioral/distributional effects or (if they occur) auditory effects could constitute "taking" under the provisions of the U.S. Marine Mammal Protection Act (MMPA) and the U.S. Endangered Species Act (ESA), at least if the effects are considered to be "biologically significant". The National Research Council's 2005 *Marine Mammal Populations and Ocean Noise* suggest that noise is "biologically significant to an individual animal when it affects the ability of the animal to grow, survive, and reproduce" (Rossiter 2005).

Numerous species of cetaceans and pinnipeds inhabit parts of the Chukchi Sea. Two species listed as "Endangered" under the ESA may occur in portions of the survey area are the bowhead whale (*Balaena mysticetus*) and perhaps the fin whale (*Balaenoptera physalus*). The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) share jurisdiction over the marine mammal species that were likely to be encountered during the project. USFWS manages two species occurring in the Chukchi Sea, the walrus (*Odobenus rosmarus*) and the polar bear (*Ursus maritimus*); NMFS manages all the other marine mammals occurring in the Chukchi Sea.

Other species of concern (birds) that might occur in the survey area are the spectacled (*Somateria fischeri*) and Steller's (*Polysticta stelleri*) eiders that are listed as "Threatened" under the ESA. Of the two species, spectacled eiders are likely to be more abundant in the project area. The USFWS designated critical habitat for the spectacled eider in Ledyard Bay on the east coast of the Chukchi Sea between Icy Cape and Cape Lisburne. No critical habitat has been designated for Steller's eider within the Chukchi Sea.

On 2 Feb. 2006, CPAI requested that the National Marine Fisheries Service (NMFS) issue an Incidental Harassment Authorizations (IHA) to authorize non-lethal "takes" of marine mammals incidental to the seismic operations in the Chukchi Sea (CPAI 2006a). The IHA was requested pursuant to Section 101(a)(5)(D) of the MMPA. An IHA to cover activities in the Chukchi Sea was issued to CPAI by NMFS on 7 July 2006 (Appendix A). The IHA authorized "potential take by harassment" of various cetaceans and pinnipeds during the marine geophysical cruises described in this report. On 10 Feb. 2006, CPAI also requested from USFWS an IHA authorizing potential "taking" of walrus and polar bears in the Chukchi Sea. The USFWS issued the IHA to CPAI on 29 June 2006 (Appendix B).

This document serves to meet reporting requirements specified in the IHAs. The primary purposes of this report are to describe the seismic survey in the Chukchi Sea, to describe the associated marine mammal monitoring and mitigation programs and their results, and to estimate the numbers of marine mammals potentially exposed to levels of sound generated by the project at or above presumed effects levels.

## *Incidental Harassment Authorization*

IHAs issued to seismic operators include provisions to minimize the possibility that marine mammals close to the seismic sources might be exposed to levels of sound high enough to cause hearing damage or other injuries. During this project, sounds were generated by the airguns on the *Western Patriot* and by several types of low energy sound sources used to determine the precise location of the airgun array behind the *Western Patriot*. No serious injuries or deaths of marine mammals were anticipated from the seismic surveys, given the nature of the operations and the mitigation measures that were implemented, and no injuries or deaths were attributed to these activities. Behavioral disturbance to marine mammals is considered to be "take by harassment" under the provisions of the MMPA, passed by Congress in 1972, amended 1994. Appendix C provides further background on the issuance of IHAs relative to seismic operations and "take".

Under current NMFS guidelines (e.g., NMFS 2006a), "safety radii" for marine mammals around airgun arrays are customarily defined as the distances within which the received pulse levels are ≥180 dB re 1 $\mu Pa_{rms}$[1] for cetaceans and ≥190 dB re 1 $\mu Pa_{rms}$ for pinnipeds. Those safety radii are based on an assumption that seismic pulses received at lower received levels will not injure these mammals or impair their hearing abilities, but that higher received levels *might* have some such effects. The mitigation measures required by IHAs are, in large part, designed to avoid or minimize the numbers of cetaceans and pinnipeds exposed to sound levels exceeding 180 and 190 dB (rms), respectively. The development and implementation of the safety radii for the current project are discussed in detail in Appendix C.

NMFS assumes that baleen whales exposed to airgun sounds with received levels ≥160 dB re 1 $\mu Pa_{rms}$ are likely to be disturbed. That assumption is based mainly on data concerning behavioral responses of baleen whales, as summarized by Richardson et al. (1995) and Gordon et al. (2004). Dolphins and pinnipeds are generally less responsive than baleen whales (e.g., Stone 2003; Gordon et al. 2004), and 170 dB may be a more appropriate criterion of potential behavioral disturbance for those groups (LGL Ltd. 2005a,b). In general, disturbance effects are expected to depend on the species of marine mammal, the activity of the animal at the time of disturbance, distance from the sound source, the received level of the sound and the associated water depth. Some individuals may exhibit behavioral responses at received levels somewhat below the nominal 160 or 170 dB criteria, but others may tolerate levels somewhat above 160 or 170 dB without reacting in any substantial manner. For example, migrating bowhead whales in the Alaskan Beaufort Sea show avoidance at received levels substantially lower than 160 dB re 1 $\mu Pa_{rms}$ (Miller et al. 1999; Richardson et al. 1999).

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[1] "rms" means "root mean square", and represents a form of average across the duration of the sound pulse as received by the animal. Received levels of airgun pulses measured on an "rms" basis (sometimes described as Sound Pressure Level, SPL) are generally 10–12 dB lower than those measured on the "zero-to-peak" basis, and 16–18 dB lower than those measured on a "peak-to-peak" basis (Greene 1997; McCauley et al. 1998, 2000a,b). The latter two measures are the ones commonly used by geophysicists. Unless otherwise noted, all airgun pulse levels quoted in this report are rms levels. Received levels of pulsed sounds can also be described on an energy or "Sound Exposure Level" basis, for which the units are dB re $(1\ \mu Pa)^2 \cdot s$. The SEL value for a given airgun pulse, in those units, is typically 10–15 dB less than the rms level for the same pulse (Greene 1997; McCauley et al. 1998, 2000a,b), with considerable variability (Madsen et al. 2006; see also Chapter 4 of this report). SEL (energy) measures may be more relevant to marine mammals than are rms values, but the current regulatory requirements are based on rms values.

A notice regarding the proposed issuance of an IHA for the survey in the Chukchi Sea was published by NMFS in the *Federal Register* on 12 May 2006 and public comments were invited (NMFS 2006b). On 31 Jul 2006, NMFS published a second notice in the *Federal Register* to announce the issuance of the IHA (NMFS 2006a). The second notice responded to 50 comments received by NMFS during the 30-day public comment period. A copy of the IHA issued by NMFS is included in this report as Appendix A.

The IHA issued for the Chukchi Sea seismic survey authorized harassment "takes" of one ESA-listed species (bowhead whale) as well as non-listed species including gray (*Eschrichtius robustus*), killer (*Orcincus orca*), and beluga (*Delphinapterus leucas*) whales, harbor porpoise (*Phocoena phocoena*), and ringed (*Phoca hispida*), spotted (*Phoca largha*), and bearded (*Erignathus barbatus*) seals.

The IHA was granted to CPAI on the assumptions that

- the numbers of marine mammals potentially harassed (as defined by NMFS criteria) during seismic operations would be "small",
- the effects of such harassment on marine mammal populations would be negligible,
- no marine mammals would be seriously injured or killed,
- there would be no unmitigated adverse effects on the availability of marine mammals for subsistence hunting in Alaska, and
- the agreed upon monitoring and mitigation measures would be implemented.

USFWS determined in 2006 that proponents of Arctic seismic projects should operate under IHAs issued by USFWS. The process of obtaining an IHA from USFWS was similar to NMFS's process. On 10 Feb. 2006, CPAI requested an IHA from USFWS for the incidental taking of walruses and polar bears in conjunction with seismic activities in the Chukchi Sea (CPAI 2006b). A notice regarding the proposed issuance by USFWS of an IHA for the survey in the Chukchi Sea was published in the *Federal Register* on 8 May 2006 and public comments were invited (USFWS 2006). This IHA was issued to CPAI by USFWS on 29 Jun. 2006. USFWS did not publish a second notice in the *Federal Register* to announce the issuance of the IHA. A copy of the USFWS IHA is included in this report as Appendix B. The IHA required CPAI to observe a 190 dB safety radius for walruses and polar bears.

## *Mitigation and Monitoring Objectives*

The objectives of the mitigation and monitoring program were described in detail in CPAI's IHA applications (CPAI 2006a,b) and in the IHA issued by NMFS to CPAI (Appendix A). Explanatory material about the monitoring and mitigation requirements was published by NMFS and USFWS in the *Federal Register* (NMFS 2006a,b; USFWS 2006).

The main purpose of the mitigation program was to avoid or minimize potential effects of CPAI's seismic survey activities on marine mammals. This required that shipboard personnel detect marine mammals within or about to enter the safety radii, and in such cases initiate an immediate power down (or shut down if necessary) of the airguns. A power down involves reducing the source level of the operating airguns, in this case by reducing the air volume. A shut down involves temporarily terminating the operation of all airguns. An additional mitigation objective was to detect marine mammals within or near the safety radii 30 min prior to starting the airguns, or during ramp up toward full power. In these cases, the start of airguns was to be delayed or ramp up discontinued until the safety radius was free of marine

mammals insofar as this can be determined visually for a period of 30 min (see Appendix A and Chapter 4).

In 2006 mitigation was also required, as specified by the IHA, at the 160 dB isopleth. This area was monitored by the chase boat that accompanied the seismic vessel. Power down of the seismic airgun array was required if an aggregation of 12 or more non-migratory bowhead or gray whales was detected ahead of, or perpendicular to, the seismic vessel track and within the 160 dB isopleth.

The primary objectives of the monitoring program were as follows:

1. provide real-time sighting data needed to implement the mitigation requirements;
2. estimate the numbers of marine mammals potentially exposed to strong seismic pulses; and
3. determine the reactions (if any) of marine mammals potentially exposed to seismic sound impulses.

Specific mitigation and monitoring objectives identified in the IHA are described in Appendix A. Mitigation and monitoring measures that were implemented during the activities in the Chukchi Sea are described in detail in Chapter 4.

This 90-day report describes the methods and results for the monitoring work specifically required to meet the above primary objectives. Various other marine mammal and acoustic monitoring and research programs not specifically tied to the above objectives were also implemented by CPAI (or by CPAI plus other industry operators) in the Chukchi Seas during 2006. Results of those additional efforts are, for the most part, not mentioned in this 90-day report. Those additional results will be presented in a comprehensive report at a later date.

## *Report Organization*

The primary purpose of this report is to describe the 2006 seismic survey activities in the Chukchi Sea including the associated monitoring and mitigation programs, and to present results as required by the IHA (see Appendix A). This report includes six chapters:

1. background and introduction (this chapter);
2. description of the seismic study;
3. sound source and propagation modeling and measurement;
4. description of the marine mammal monitoring and mitigation requirements and methods, including safety radii; and
5. results of the marine mammal monitoring program, including estimated numbers of marine mammals potentially "taken by harassment".

Those chapters are followed by Acknowledgements and Literature Cited sections.

In addition, there are nine Appendices which provide details of procedures that are more-or-less consistent during seismic surveys where marine mammal monitoring and mitigation measures are in place. These procedural details are only summarized in the main body of this report. The Appendices include

A. a copy of the IHA issued by NMFS to CPAI for this study;
B. a copy of the IHA issued by USFWS to CPAI for this study;

C. background on development and implementation of safety radii;
D. characteristics of the *Western Patriot*, *Torsvik*, *Gulf Provider,* and *Peregrine*;
E. details on visual and acoustic monitoring, mitigation, and data analysis methods;
F. conservation status and densities of marine mammals in the project region;
G. monitoring effort and list of marine mammals seen or heard during this cruise;
H. marine mammal sightings with power downs and shut downs during the seismic activities; and
I. marine mammal density estimates for the project area.

# 2. SEISMIC SURVEY DESCRIBED

## *Chukchi Sea*

The *Western Patriot* was used as the source vessel during CPAI's activities in the Chukchi Sea in 2006. The *Western Patriot* was accompanied by a support vessel (chase vessel), the *Torsvik*. The *Gulf Provider* was used as a supply vessel for transfer of personnel during crew changes, for fuel transfers to the *Western Patriot*, and to resupply the *Western Patriot* with equipment and supplies. The *Gulf Provider* was occasionally used as the *Western Patriot's* chase boat when the *Torsvik* was occupied with other duties such as scouting for ice locations, or conducting marine mammal surveys. In addition, the *Peregrine*, a flat-bottom landing craft with minimal draft, was used for transfer of personnel and equipment from shore areas to the *Torsvik* and *Gulf Provider*. Appendix D contains a description of the vessels used during the seismic activities. These four vessels operated in accordance with the provisions of a Conflict Avoidance Agreement (CAA) between the seismic industry and the Alaska Eskimo Whaling Commission (AEWC) and the Whaling Captains Associations and with respect to other subsistence activities including but not limited to an organized beluga whale hunt. The objective of the CAA was to provide avoidance and other mitigation guidelines to be followed by industry participants working in or transiting the vicinity of active whaling crews. Under the terms of the CAA, communication centers were established at Barrow and Deadhorse, and call centers at Pt. Hope, Pt. Lay, Wainwright, and Kaktovik. The CAA outlined a communication program and specified times and areas to be surveyed in order to avoid any possible conflict with the subsistence hunts.

### *Operating Areas, Dates, and Navigation*

The geographic region where the deep seismic survey occurred was located in the Chukchi Sea MMS OCS Program Areas designated as Chukchi Sea Lease Sale 193 (1989) (see Fig. 2.1). Since the Chukchi Sea deep seismic program was conducted as a pre-lease activity, the exact locations where operations occurred remains confidential. Companies producing ≥1.6MM BOE (million barrels of oil equivalent) are prohibited from collaborating or sharing data prior to a lease sale or they run the risk of forfeiting all leases obtained during the sale without refund of bid dollars. The 3D seismic data acquired in 2006 will be used by CPAI to identify leases on which it may bid in a forthcoming competitive lease sale. In general, seismic acquisition occurred in the Chukchi Sea well offshore from the Alaska coast in OCS waters averaging greater than 40 m deep and outside the polynya zone.

The *Western Patriot* left Dutch Harbor on 15 July to travel to the project area, and entered the Chukchi Sea on ~21 July. CPAI's seismic contractor began deploying the seismic acquisition equipment on 23 July. After deployment of the airguns, the underwater sounds produced by the airgun array were recorded and analyzed to verify or refine the various radii to be used for mitigation purposes during the exploration activities (see Chapter 3 below). Those radii had been predicted prior to the field season via acoustic modeling procedures (see Chapter 3), but site-specific empirical measurements were required to confirm or refine the predictions. The airgun sounds were recorded as a function of airgun configuration, distance, and aspect on 24 and 25 July, and safety and disturbance radii based on these measurements were determined within 72 hrs. Data were reported to NMFS as required in the IHA. Seismic acquisition began on 27 July 2006 and continued through most of the field season until 6 Oct. CPAI then determined that ice conditions and other operational considerations precluded continuation of the exploration program, and seismic activities were terminated. CPAI completed ~16,028 km (9959 statute mi) of deep-seismic survey line (roughly, over an area of 7766 $km^2$) in the Chukchi Sea in 2006; the surveyed area is ~5.6% of the total lease sale area (137,594 $km^2$).

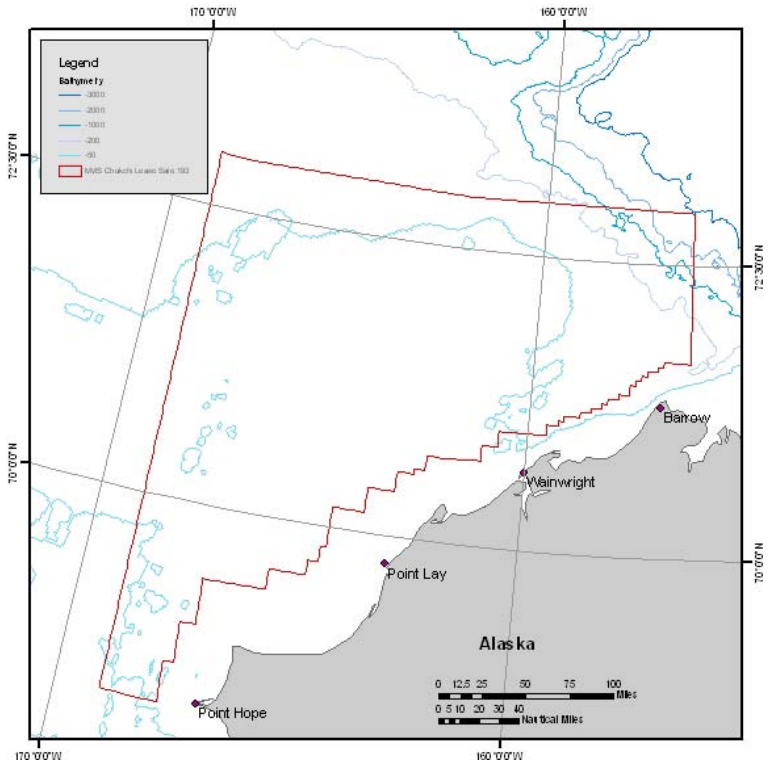


FIGURE 2.1. Location of the proposed MMS Chukchi Sea Lease Sale 193 within which CPAI seismic activities were conducted (~5.6% of the total lease area).

Throughout the survey the *Western Patriot's* position, speed, and water depth were logged digitally every ~60 s. In addition, the position of the *Western Patriot*, water depth, and information on the airgun array were logged for every airgun shot while the *Western Patriot* was on a seismic line and collecting geophysical data. The geophysics crew kept an electronic log of events, as did the marine mammal observers (MMOs) while on duty. The MMOs also recorded the number and volume of airguns that were firing when the *Western Patriot* was offline (e.g., prior to shooting at full volume) or was online but not recording data (e.g., during airgun or computer problems).

## *Airgun Characteristics*

CPAI used WesternGeco's 3390 $in^3$ array of Bolt airguns for its 3–D seismic survey operations in the Chukchi Sea. Two 3390 $in^3$ arrays that could be fired alternately were towed side by side behind the *Western Patriot*. Each array was composed of two 1695 $in^3$ sub-arrays operating at 2000 psi of air pressure. Each sub-array was composed of six tuning elements, two 2-gun clusters, and four single guns. The individual airguns ranged in volume from 105 to 290 $in^3$. Each sub-array included two 2-gun clusters, one composed of two 290 $in^3$ airguns, and the other composed of two 195 $in^3$ airguns, and four individual guns. Each sub-array was 15 m in length and the sub-arrays were 10 m apart. This energy source was towed ~242 m behind the *Western Patriot*. The system also included 6 hydrophone streamers 2500 m in length, which recorded reflected sound energy. In general, the *Western Patriot* towed this system along a predetermined survey track although adjustments were made during the course of the field season in accordance with ice conditions.

Air compressors aboard the *Western Patriot* were the source of high pressure air used to operate the airgun arrays. Seismic pulses were emitted at intervals ~50 m while the *Western Patriot* traveled at a

speed of 4-5 knots (7.4–9.3 km/h). The airgun arrays were towed at a depth of 6 m. Characteristics of the airgun arrays are detailed in Appendix D.

### *Echo-sounder and Pinger*

CPAI also operated two additional acoustic systems throughout the study. The Simrad EA500 echo-sounder operated at 200 kHz, with a maximum output of 185 dB at 1 m, and the beam directed downwards with a width up to 33°. The Sonardyne SIPS-2 acoustic positioning system operated at 55-110 kHz, with a maximum output of 183 dB at 1 m, and an omnidirectional beam. This equipment was used to determine the precise location of the airgun arrays and the hydrophone cable being towed behind the *Western Patriot*.

# 3. SUMMARY OF NOISE ASSESSMENT[2]

This chapter presents a summary of the underwater sound assessments performed for ConocoPhillips's 2006 Chukchi seismic survey program. The underwater acoustics assessments comprised pre-season computer modeling of noise emissions from the airgun systems, followed by field acoustics verification measurements of the airgun systems. The pre-season model results were presented at the open water meetings in Anchorage in April 2006 and are described in greater detail in the report by Austin and Zykov (July 2006). Model results were used to define preliminary marine mammal exclusion zones that were implemented for the first three days of the seismic survey, until verification measurements were available. The verification measurements were made on 24-25 July, 2006 during a dedicated measurement program of airgun array shooting just prior to the start of the seismic survey. Measurements of root-mean-square (*rms*) sound level as function of distance from the airgun array in endfire and broadside directions were presented in the 72-hour field report by Turner et al. (July 2006). Those results were used to establish marine mammal exclusion zones that were implemented for the remainder of the seismic program. A detailed analysis of the verification data is presented in ConocoPhillips's acoustics report by MacGillivray and Hannay (January 2007).

A goal of the combined modeling/verification measurement approach was to ground-truth computer model results and to help refine model applicability for predicting sound levels produced by airgun array over large areas, to be used for impact assessment and for defining marine mammal safety/exclusion zones. Because the model and verification measurements were performed at different locations, a post season model study was performed at the actual measurement site. The comparison of the post-season model results with verification measurements is discussed in the report by MacGillivray and Hannay, and key findings of that analysis discussed in Section 3.3.

## *Acoustic Modeling*

A computer noise model was used to predict sound levels in the vicinity of the ConocoPhillips seismic survey operations for the purpose of estimating takes of marine mammals, and for predicting the initial marine mammal exclusion zones. The model was first used for estimating takes prior to the field season by simulating the sound levels produced by the seismic program's airgun array at a test location in the Chukchi Sea (Austin and Zykov). An additional model run at the verification measurement site was made after the field season to compare directly with the measurements (MacGillivray and Hannay).

The model generates estimates of received sound level as a function of direction and distance from the airgun array system. Pre-season model predictions were analyzed to compute sound level maps showing isopleths at 190 dB re μPa to 120 dB re μPa (*rms*) in 10 dB steps at a test location in the Alaskan Chukchi Sea. A set of radii were generated from these non-circular isopleths to indicate nominal distances at which sound levels reached the corresponding thresholds. These radii are referred to as *95% radii* because they are the radii of the smallest circles containing 95% of the areas ensonified at or above the respective sound level thresholds. Circular exclusion zones based on the 95% radii were used instead of the non-uniformly shaped isopleths to simplify implementation in the field by marine mammal observers.

The acoustics model was re-run after verification measurements to provide results at the actual verification measurement site that could be compared directly with data. This model analysis included

[2] By Alex MacGillivray and David Hannay, JASCO Research Ltd., 2101-4464 Markham Street, Victoria, B.C. Canada, V8Z 7X8.

testing the model's sensitivity to bottom type uncertainty and source depth uncertainty. Section 3.3 presents key features of the analysis and provides a summary of the detailed comparison that is given in the report by MacGillivray and Hannay.

### *Airgun Noise Model*

JASCO Research's Marine Operations Noise Model (MONM) is an integrated sound prediction model comprised of an airgun array source model and an acoustic propagation model. It computes 3-dimensional sound fields produced by seismic surveys, accounting for the influences of ocean sound speed variations, bathymetry and geoacoustic parameters of the seabed.

The internal airgun array source model (AASM) predicts composite sound pressure signatures of airgun array systems (MacGillivray, 2006). It simulates the throttled injection of high-pressure air from individual airgun chambers into underwater air bubbles. The model then simulates the complex oscillation of each bubble, taking into account the pressure effects of the pressure waves from all other airguns in the array. It includes effects from surface-reflected pressure waves, heat transfer from the bubbles to the surrounding water, and the buoyancy of the bubbles themselves. The output of AASM is a set of high-resolution pressure signatures for the airguns in the array. These pressure signatures are fed to a directivity system that applies appropriate time delays and amplitude scaling to compute an overall airgun array pressure signature in any direction.

AASM was applied here to model Western Geco's two-string 3390 cu inch seismic array that was used for the seismic survey. Examples of the model output for this array in the broadside (sideways to tow direction) and endfire (directly behind the array) in the horizontal plane are given in Figure 3.1. Separate arrivals of primary pulse pressure signatures from the two array substrings are apparent in the expanded broadside signature (Fig. 3.2). The modeled directivity patterns as a function of frequency are shown in Figure 3.3.

A wide-angled parabolic equation (PE) acoustic propagation model is utilized within MONM. The specific PE code is based on the Naval Research Laboratory's Range-dependent Acoustic Model (RAM). This code has been benchmarked for accuracy and is widely employed in the underwater acoustics community (Collins, 1993). The model has been augmented to account for shear wave losses in the seabed using a complex density approach (Zhang and Tindal, 1994).

MONM computes acoustic fields in three dimensions by modeling transmission loss along evenly spaced 2-D radial traverses covering a 360º swath from the source. This approach is referred to as N×2-D. MONM fully treats variations of several environmental parameters including bathymetry and sound speed profiles in the water column and the sea floor. It also treats layer reflection losses incurred by downgoing compressional waves that partly convert to shear waves. Compressional wave and shear wave attenuations are specified in all layers. The model samples the acoustic environment at a predetermined range step along radial traverses.

Frequency dependence is treated by computing acoustic transmission loss at the center frequencies of all 1/3-octave bands between 10 Hz and 2 kHz. This frequency range includes the important bandwidth of noise emissions for airgun array systems. 1/3-octave band received levels are computed by subtracting band transmission loss values from the band source levels. Broadband received levels are computed by summing the received band levels. MONM's sound level predictions have been validated against experimental data (Hannay, 2004).

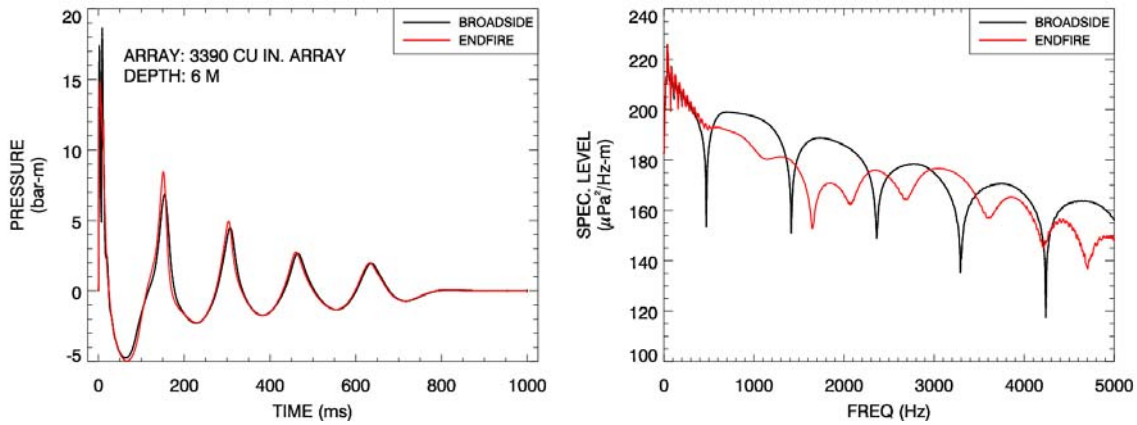


FIGURE 3.1. Broadside (black) and endfire (red) overpressure signatures and power spectra for the 3390 cu in array, at a source depth of 6m. Surface ghosts are not included in these signatures.

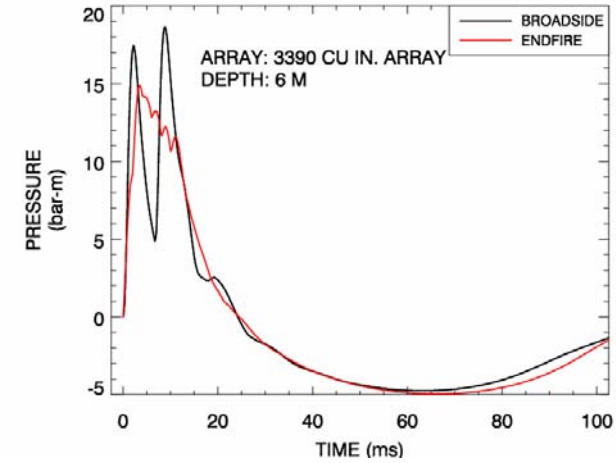


FIGURE 3.2. Broadside (black) and endfire (red) overpressure signature for the first 100 ms.

## *Pre-Season Model Summary*

Broadband unweighted Sound Exposure Level (SEL) and root mean square (*rms*) noise levels were computed by the MONM model prior to the field season for a test scenario at the Burger well in the Alaskan Chukchi Sea. This location is shown in the map in Figure 3.4.

A new frequency weighting scheme, referred to as M-weighting (for marine mammals), was applied to take into account the frequency dependence of hearing for mid-frequency cetaceans (Belugas) and for pinnipeds (seals, sea lions and walruses). The weighting relies on the model's ability to predict the absolute sound levels as a function of frequency. In practice we applied the M-weight values, computed at the center frequencies of the bands, to the SEL of respective bands.

M-weighting for low-frequency cetaceans (Bowheads) had little effect on the predicted sound levels since these animals can hear the full frequency band of airgun noise emissions. Effective 180 dB *rms* flat-weighted and M-Weighted radii to levels between 120 dB and 190 dB *rms* were computed based on the weights applied to SEL levels, prior to conversion to *rms*. The resulting *rms* levels are presented in Table 3.1.

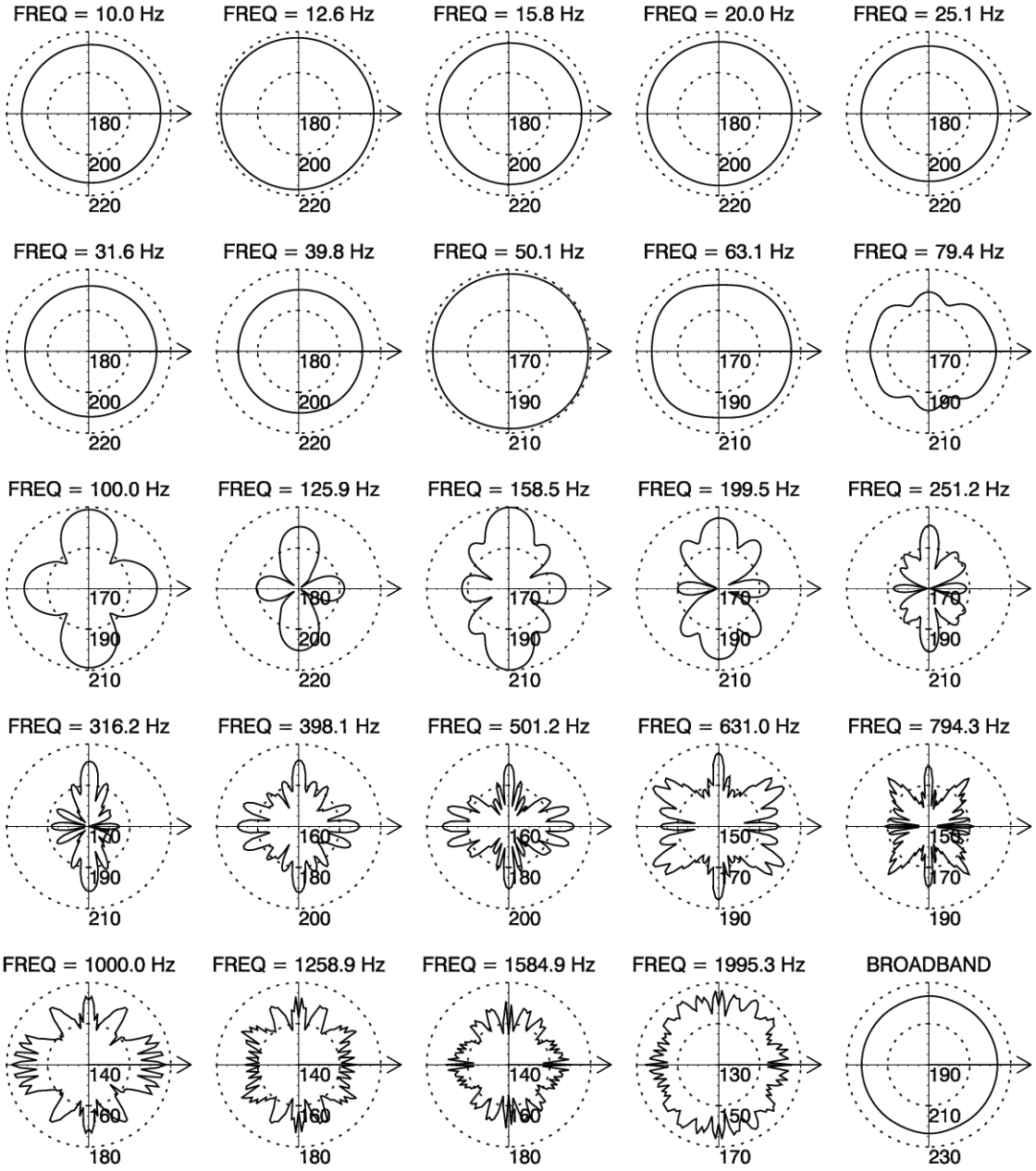


FIGURE 3.3. Airgun Array directivity patterns in the horizontal plane of the array, computed by AASM for frequencies from 10 Hz to 2 kHz. Broadband pattern is shown in bottom right corner.

## *Source Verification Measurements*

Source verification measurements were carried out to measure the sound level transmission characteristics of the airgun array systems and to determine the actual distances to several sound level thresholds.

The sound level verification measurement study was performed on 24-25 July, 2006, just prior to the start of ConocoPhillips's Chukchi Sea seismic exploration program. Acoustic measurements were performed using an array of three of JASCO Research's autonomous Ocean Bottom Hydrophone (OBH)

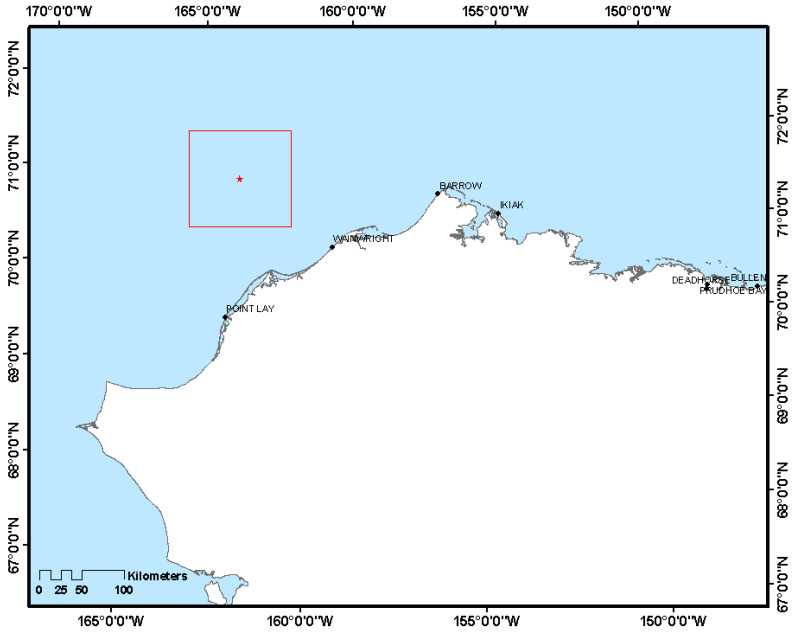


FIGURE 3.4. Pre-season model location in the Chukchi Sea. Red star indicates source location; the model extent is indicated by the box drawn around the source location.

TABLE 3.1. Pre-season model estimates of rms threshold radii, based on a receiver at 10 m depth.

| ***RMS*** **[dB re μPa]** | **Radius encompassing 95% of contour area [km]** | | |
|---|---|---|---|
| | **Flat-Weighted (Bowhead Whale)** | **M-weighted** | |
| | | **Mid Freq Cetacean** | **Pinnipeds in Water** |
| 120 | 23.53 | 17.44 | 21.34 |
| 130 | 16.26 | 11.56 | 14.61 |
| 140 | 10.77 | 7.62 | 9.67 |
| 150 | 7.48 | 5.28 | 6.68 |
| 160 | 4.59 | 3.14 | 4.14 |
| 170 | 2.05 | 1.28 | 1.91 |
| 180 | 0.85 | 0.45 | 0.72 |
| 190 | 0.23 | 0.21 | 0.21 |

recorder systems that were deployed on a line perpendicular to the survey track of the primary survey vessel — the *M/V Western Patriot*, operated by WesternGeco. The three OBH systems were deployed from the support vessel Torsvik and recorded acoustic waveform data for approximately 21 hours while the survey vessel traveled along a pre-planned survey track. The OBH locations included one directly on the survey track with the second and third positioned to the side of the track at distances 500 m and 2 km off the track.

The *Western Patriot's* primary airgun array source had two identical 1795 cu in strings of 8 guns each for a total capacity of 3390 cu. in. The array was towed behind the survey vessel at a nominal depth of 6 meters.

### *Location*

The source verification measurements were carried out on in the Alaskan Chukchi Sea approximately 150 km west of Point Lay, as shown in the map of Figure 3.5(a). Due to the presence of sea-ice, the source verification measurements were performed at a different location than the pre-season acoustic modeling. Sound levels from the *Western Patriot*'s airgun arrays were measured at three fixed recording stations, in 46 meters nominal water depth. The three stations, designated A, B and C, were situated at 0 m, 500 m and 2 km range respectively from the closest point of approach (CPA) along the planned survey track. However, that the *Western Patriot* deviated slightly from the planned survey track and so the closest point of approach of the vessel to the nearest OBH system was 150 meters horizontally.

### *Acoustic Environment*

The shallow water depth environment strongly influenced acoustic propagation at the source verification test site. The nominal water depth at the OBH deployment location was 46 meters and depth varied by only a few meters over the track line of the survey vessel. Sound propagation in shallow water is very strongly affected by the bottom type since sound is trapped in the water column primarily by reflections from the seabed. If the bottom materials are acoustically reflective (e.g., sand or rock) then received sound levels will be significantly higher than over a soft, absorptive bottom (e.g., mud or silt). Published sediment data near the test site indicated that the seabed type was acoustically reflective at this location: nearby grab samples were ~50% sand and a drill core taken 60 km west of the measurement site reported low porosity sediments, which were described as "silty sand" (McManus and Creager 1965, Winters and Less, 1984). Prominent normal-mode structures (bands of energy in the spectrograms) in the acoustic data also provided strong evidence for an acoustically reflective seabed at the test site (MacGillivray and Hannay, 2007).

The sound speed profile in the water column is also an important property that affects acoustic propagation in shallow water. The sound speed profile depends on both the temperature and salinity of the water column; thus, the shape of the sound speed profile typically depends on the time of year, since it follows seasonal temperature and salinity cycles. Figure 3.6(a) shows the temperature and salinity profiles that were measured at the test site on 25 July 2006 using a SeaBird SBE-19 CTD profiler. These data show the presence of a warm, brackish surface layer in the top 10 meters of the water column that overlies a well mixed bottom layer of colder, saline water. This surface layer was caused by melting sea ice and solar heating associated with the summer months in the Arctic. The resulting sound speed profile, shown in Figure 3.6(b), was only slightly downward refracting, since the effects of warmer surface temperature (causing higher sound speed) and brackish surface salinity (causing lower sound speed) partially offset each other.

### *Airgun Array Pressure Characteristics*

Figure 3.7 shows spectrograms of measured pressure waveforms from the 3390 cu. in. airgun array at four different distances from the source. These plots illustrate how the dispersive propagation characteristics of the shallow water environment (~45 m depth) at the measurement site influenced the time/frequency evolution of the airgun pulse power spectrum with range. Figure 3.7(a) shows the airgun pulse measured at 150 m range: at this distance from the array most of the energy in the pulse was concentrated in a brief 100 msec window and there was no obvious frequency dispersion (the low frequency tail after the main arrival corresponds to the airgun bubble pulses). The tonal background noise in this spectrogram was from the survey vessel. In Figure 3.7(b), at 1 km range, the airgun pulse started to exhibit geometric dispersion (i.e., spreading out in time) at the lower frequencies.

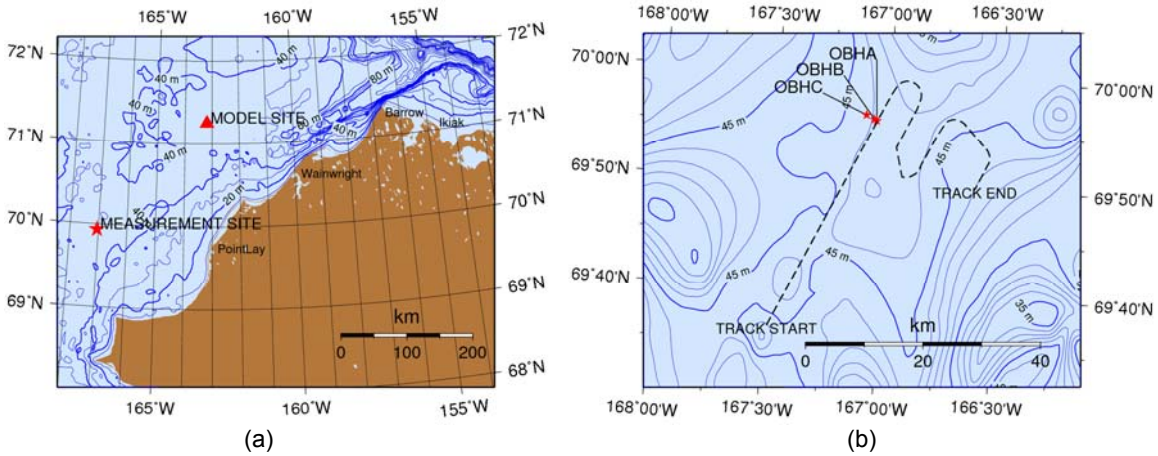


FIGURE 3.5. (a) Map of Alaskan Chukchi Sea showing locations of pre-season modeling site and verification test site. (b) Map of verification test site showing *Western Patriot's* track line, bathymetry and OBH deployment locations.

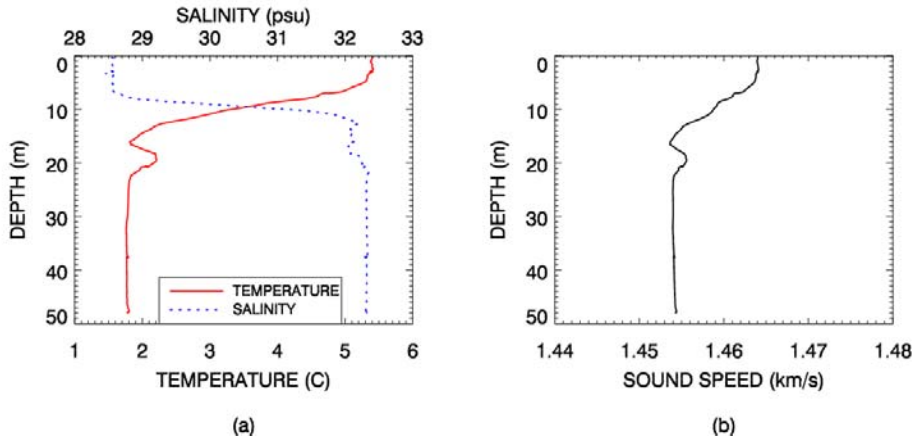


FIGURE 3.6. (a) Temperature and salinity profiles taken at the source verification test site. (b) Sound speed profile derived from temperature and salinity data.

Figure 3.7(c) shows the airgun pulse spectrogram at 10 km range. The normal modes of the airgun pulse (the descending bands of energy in the plot) were very pronounced and the total duration of the signal increased to over 6 seconds (the 90% pulse duration of this shot was 1400 msec). The long tail of the airgun pulse indicates that the bottom sediments had large P-wave speed at the measurement location; a slower-speed bottom would not have supported the corresponding mode to such low frequencies. At this range, an infrasonic precursor wave at 8 Hz was observed to arrive several seconds before the waterborne arrival. This low frequency ground-wave is predicted by normal mode theory and corresponds to seismic energy that has traveled from the airgun array to the OBH recorder, predominantly through the seabed.

It is apparent in Figure 3.7(d), showing a received airgun shot at 40 km range, that sound energy below 60 Hz was stripped from the airgun pressure wave and the airy phase (i.e., the long "tails" of the normal modes) was truncated. The loss of low frequency energy and the shortening of the pulse duration both indicate that the survey vessel moved to an area where the seabed type changed to a softer (i.e., more absorptive) material. Over a soft bottom the mode cutoff frequency (lowest supported frequency of

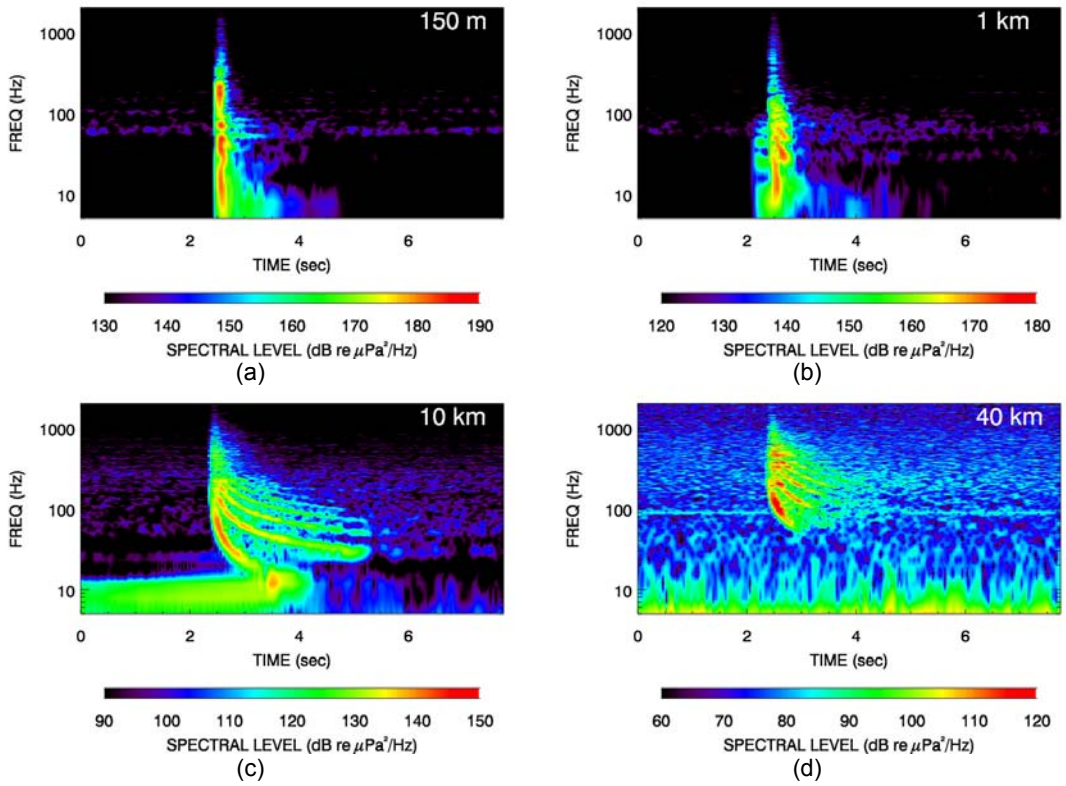


FIGURE 3.7. Spectrogram plots of measured waveforms from the full 3390 cu. in. array at different distances in the endfire direction from the source: (a) 0.15 km, (b) 1 km, (c) 10 km and (d) 40 km.

propagation in the water) is greater. This leads to poorer support of low frequency sound propagation. The transition from reflective bottom type to absorptive bottom type, which was also very obvious in the pulse duration data, appears to have occurred at approximately 20 km range from the source. At this range we observed the low frequency content of the signals to be much more rapidly attenuated than at shorter ranges. This led to the lack of low frequency energy that is apparent in Figure 3.7(d). This observation demonstrates the degree to which bottom type variability can influence sound propagation.

The 100 Hz tone also apparent in the background of Figure 3.7(d) is due to self-noise from the OBH recorder's hard disk and is not related to airgun or survey vessel noise.

### *Airgun Array Sound levels*

The recorded sound pressure data on all three OBH systems were processed to compute the sound level metrics: peak pressure, *rms* pressure and sound exposure level (SEL) versus range for all three array configurations. Those levels are presented and discussed in detail in the report by MacGillivray and Hannay. The levels in endfire and broadside directions for the array are presented in Figure 3.8(a) and 3.8(b) respectively. The *endfire* data discussed in this report include all sound level data obtained for angles greater than 25 degrees from the direction perpendicular to the array tow direction. The *broadside* data are the maximum sound levels measured to the side of array as the survey vessel passed to the side of the OBH's on each leg of the survey track.

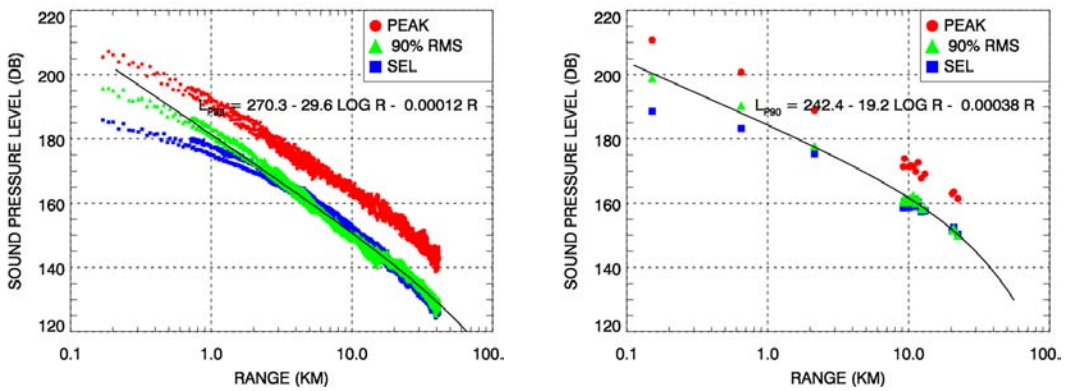


FIGURE 3.8. Graphs of peak level, *rms* level and SEL versus range for the 3390 cu. in. airgun array: (a) endfire aspect and (b) broadside aspect. Best-fit to *rms* transmission loss equation parameters and coefficients are shown.

Measured sound levels were greatest in the array's broadside direction (i.e., perpendicular to the array substrings) where the pressure signatures from the individual airguns in each substring added coherently. The difference between the broadside and endfire broadband *rms* level varied from ~3 dB at 1 km distance to ~10 dB at 20 km distance. The variation in difference is attributed to the range dependence of the frequency-content of the measured signals; at longer ranges the relative importance of sound frequencies near 100-300 Hz was greater. Directivity in this mid-frequency band was greater than at low frequencies.

The lowest measured level at 40 km was approximately 125 dB re µPa *rms*. In order to extrapolate the range to the 120 dB re µPa threshold, measured sound pressure levels versus range were fit using a least squares method to an empirical propagation loss equation of the form:

$$RL = SL - A\log_{10} R - BR, \qquad (1)$$

where $R$ is the range from the source, $RL$ is the received sound level, $SL$ is the source level term, $A$ is the geometric spreading term and $B$ is the absorptive term. The best-fit parameters for $SL$, $A$ and $B$ are shown as annotations in Figure 3.8. The empirical propagation loss curve of Equation 1 well-approximated the observed decay of the *rms* sound pressure level data with range.

The results indicate that the 180 dB distance was 30–50% greater at array broadside than at array endfire; however, the 190 dB distance was similar in both directions. This result is due to the relatively high low-frequency signal content at very short range.

The empirical equation fits (using Equation 1) for both endfire and broadside directions were used to compute representative distances to sound level thresholds between 190 dB and 120 dB re uPa in 10 dB steps. These distances, with estimates of the uncertainty for endfire ranges to each threshold, are given in Table 3.2. Uncertainties for broadside direction threshold ranges are not provided due to the sparseness of broadside data.

## *Comparison of Model Predictions with Verification Measurements*

The initial comparison of verification measurements with pre-season model results found that the measurements on average exceeded pre-season model predictions by approximately 3-5 dB. While this is

TABLE 3.2. Ranges to flat-weighted *rms* sound pressure level thresholds at the verification measurement site for a receiver at bottom depth.

| ***Rms* SPL threshold (dB re µPa)** | **Distances** | | |
|---|---|---|---|
| | *Endfire range (km)* | *Endfire uncertainty (km)* | *Broadside range (km)* |
| 190 | 0.51 | .05 | 0.52 |
| 180 | 1.1 | 0.15 | 1.6 |
| 170 | 2.4 | 0.6 | 4.7 |
| 160 | 5.1 | 1. | 11.4 |
| 150 | 10.5 | 2. | 22.7 |
| 140 | 20.9 | 5. | 37.8 |
| 130 | 38.6 | 6. | 55.7 |
| 120 | 65.6 | 10. | 75.4 |

a fairly small difference in decibel level, it leads to quite substantial differences in the distances to important sound level thresholds, by factors of approximately 1.4 to 1.8 (assuming spherical spreading loss). Two possible reasons for the discrepancy were the environmental differences between the pre-season model run site and the verification measurement location, and the difference in receiver depths; the pre-season model results were calculated for a test receiver at 10 m depth while the measurements were made using bottom recording systems at 44 m depth.

To facilitate a better comparison, we performed an updated post-season model run at the location of the verification measurements. Model results were generated at depths spanning the entire water column to investigate the variation in sound level with depth. The analysis also tested the model sensitivity to errors caused by incorrectly specified bottom type by considering the differences in sound level estimates produced for: 1.) An acoustically absorptive bottom, 2.) an intermediate bottom type based on the geological description of area sediments at the verification site, and 3.) a more reflective bottom. The velocity profiles used for the three different seabed types were as follows:

| **Seabed velocity profiles for the three bottom types tested** | | | | | |
|---|---|---|---|---|---|
| *Default (intermediate)* | | *Absorptive* | | *Reflective* | |
| z (m) | $c_p$ (km/s) | z | $c_p$ (km/s) | z | $c_p$ (km/s) |
| 0 | 1.7 | 0 | 1.6 | 0 | 1.9 |
| 2 | 1.8 | - | - | 2 | 2.0 |
| 20 | 1.9 | - | - | 20 | 2.1 |
| 170 | 2.05 | 170 | 1.77 | 170 | 2.25 |
| basement | 3 | basement | 2.8 | basement | 3.2 |

Model runs were performed for the three environments described above to compute Sound Exposure Level (SEL). SEL was used instead of *rms* sound levels for these comparisons because the model outputs SEL directly and SEL is more straightforward to compute from the data because it does not rely on a representative pulse duration.

*Rms* levels were as much as 10-15 dB greater than SEL values at the closest ranges (less than 500 m). The difference between *rms* levels and SEL decreased with increasing range to near 0 dB at approximately 6 km range and beyond. The numerical difference between the two metrics is related to the effective duration parameter that is inherent in calculating *rms* levels. The accepted method for choosing the *rms* duration is based on the times at which 5% and 95% of the cumulative pulse energy has

arrived. *Rms* levels computed this way are often referred to as 90% *rms* levels. At locations close to the source the pulse duration is much shorter than 1 second and the *rms* level as a result is greater than the SEL. As distance increases, reverberation extends the length of the pulse thereby reducing the difference. As the duration approaches 1 second the *rms* level approaches SEL. In some cases the duration exceeded 1 second thereby making *rms* levels slightly less than SEL. A detailed discussion of the observed variation of pulse duration for the verification measurements with distance from the source is given by MacGillivray and Hannay.

Modeled and measured SEL levels as a function of range in both the endfire and broadside aspects are presented in Figure 3.9(a) and (b) respectively. These plots show the corresponding model results for the three bottom reflectivity types. All results are representative of a receiver at 1 m above the seabed to correspond with the depth of the hydrophone of the OBH recorder.

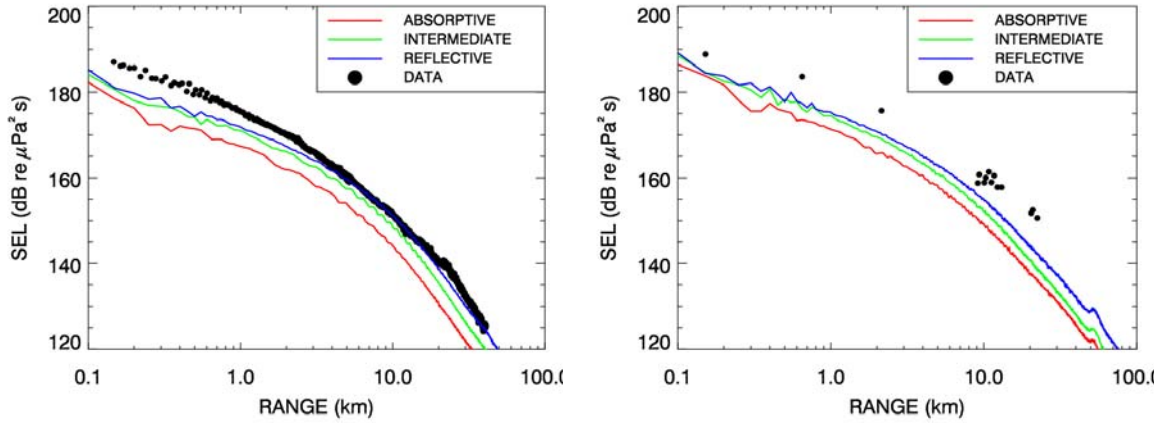


FIGURE 3.9. Modeled SEL versus distance from source for (a) endfire direction, (b) broadside direction, for three different bottom types.

The model predictions for all three bottom types tested generally underestimated measured levels in both the endfire and broadside directions. Measured SEL in the endfire direction exceeded model results for the intermediate bottom type at the closest range (150 m) by approximately 6 dB. The difference between measurements and model predictions decreased with increasing range, to approximately 4 dB at 1 km, and 2 dB at 10 km. At greater ranges the endfire mismatch was between 2 dB and 4 dB.

Measured SEL levels in the broadside direction exceeded model predictions by 5-7 dB for ranges less than 10 km, and by almost 10 dB at 22 km.

## *Variation of Model Results with Bottom Type*

Bottom sound speeds used for the acoustic modeling at the verification test site were defined based on general geological descriptions of the area, which were themselves based on bottom samples and a single drill core 60 km away that penetrated only to 20 m. The lack of direct seabed layer sampling at the verification site led to significant uncertainty in the real layer speeds, which could be responsible for errors in the model results. To test the influence of bottom type uncertainty, we modeled three different bottom type scenarios: an acoustically absorptive bottom, an intermediate bottom and a reflective bottom.

The intermediate bottom type is based on the best estimate of layer speeds from the available geological descriptions. The absorptive and reflective types were defined respectively by the estimated lower and upper limits of uncertainty in layer sound speeds. Other geoacoustic parameters such as shear speeds and attenuation coefficients were not adjusted. Errors in those parameters could lead to further changes in model results; however, we expect layer speeds to have the greatest influence, at least in the first 10 km range interval. Compressional attenuation in the seabed layers could be more influential at longer ranges, since a large fraction of lower-frequency acoustic energy could travel in the seabed to long distances if attenuation coefficients were low.

SEL levels versus range for absorptive, intermediate and reflective bottom types are given in Figure 3.9. The sound speeds in the layers of these respective bottom types are given in Table 3.2.

The modeled SEL levels for the high bottom speed reflective bottom were highest at all ranges, with the absorptive bottom producing the lowest levels. The SEL results for intermediate and reflective bottoms were in fact quite similar at short ranges for both endfire and broadside directions, differing by approximately 1 dB out to 3 km range, then diverging gradually to 4 dB at 40 km. The difference in SEL for intermediate and absorptive bottom types was near 5 dB for all ranges beyond 1 km. Even though the decibel differences between model results for different bottom types were quite small (maximum difference between results for absorptive and reflective bottoms was 8 dB), the difference in ranges to given thresholds could be quite large. For example, the endfire ranges to 120 dB SEL for aborptive and reflective bottom types were respectively 32 km and 48 km. The corresponding distance to 120 dB SEL, extrapolated from measurements to 124 dB, is 44-46 km.

## *Frequency Distribution of Sound Energy*

A comparison of modeled SEL and measured levels as a function of frequency was carried out. Modeled and measured SEL levels in 1/3-octave frequency bands were plotted in SEL isopleths graphs versus frequency band and range (Fig. 3.10 and Fig. 3.11). Model results are based on the intermediate bottom type layer speeds.

The 1/3-octave band SEL versus range and frequency from measurements and model predictions are given in **Error! Reference source not found.** and **Error! Reference source not found.** respectively for the endfire and broadside directions. The model correctly predicts the general frequency distributions quite well but appears to underestimate levels. Specific features of the comparison are:

- In the endfire direction in the nearfield (less than 1 km from the airgun array), modeled distribution of sound energy matches the measured distribution. At longer ranges the model does not predict the more rapid attenuation of low frequency energy below 100 Hz observed in measurements. This may be due to a too-low attenuation coefficient input to the model for the bottom layers.
- In both broadside and endfire directions the model results are approximately 5 dB too low at all frequencies at small ranges. This suggests the source level used was too small, or that interference from the surface reflection near the source was over-predicted by the transmission loss model. This is the primary reason for underestimation of levels at all ranges.
- In the broadside direction the model correctly predicts the bi-modal frequency distribution (peaks at 50 Hz and 200 Hz) observed in the measurements.
- The enhanced long-range propagation at broadside for 200 Hz – 300 Hz sound energy is predicted well by the model.

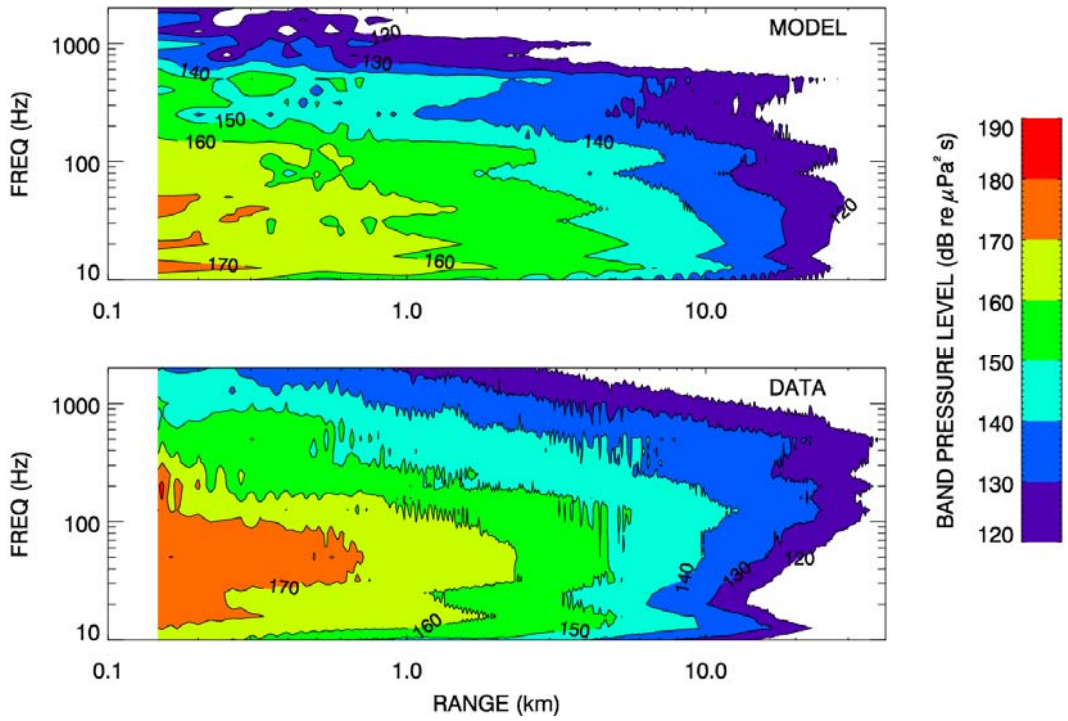


FIGURE 3.10. SEL in 1/3-octave bands at bottom depth versus frequency and range for model and data (measurements) in endfire direction. Model results are for intermediate reflectivity bottom type.

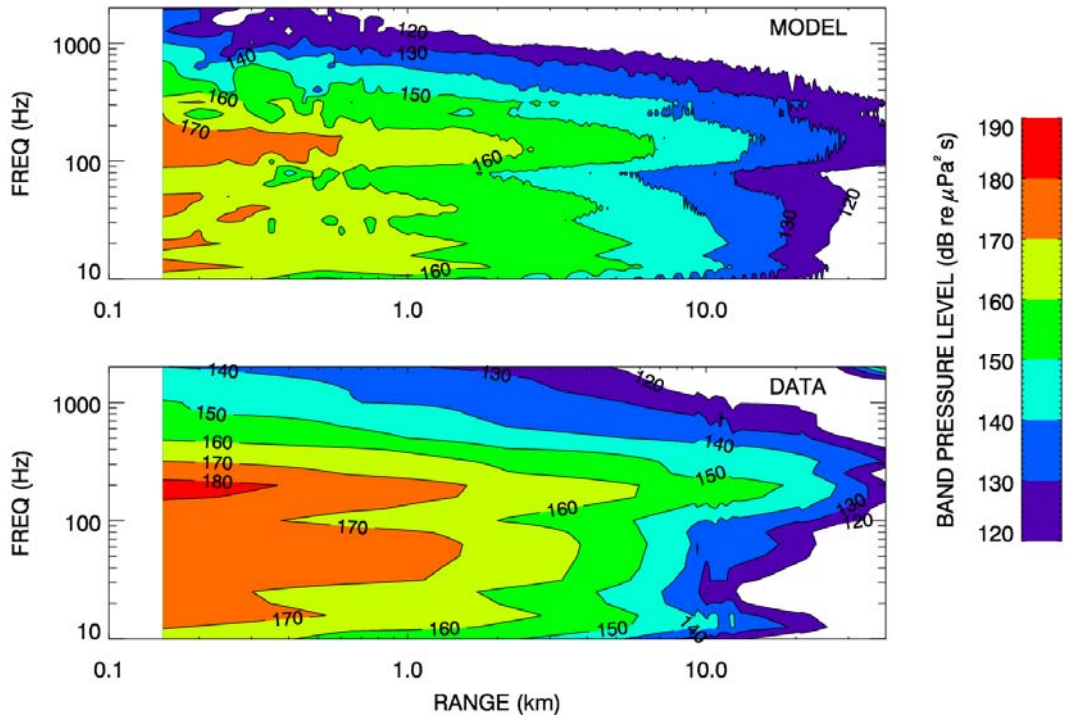


FIGURE 3.11. SEL in 1/3-octave bands at bottom depth versus frequency and range for model and data (measurements) in broadside direction. Model results are for intermediate reflectivity bottom type

## *Sound Level Variation with Depth*

Sound levels are expected to vary with depth due to interference between sound waves reflected from the surface and bottom. Generally sound levels increase with depth in shallow water, and this feature was suspected as the probable cause for some of the differences observed between the pre-season model sound level estimates, calculated for a test receiver at 10 m depth, and the verification measurements made at the bottom in 46 m water depth. The broadband modeled SEL level at the verification site was graphed as a function of depth and range for the endfire and broadside directions (Fig. 3.12 and Fig. 3.13 **Error! Reference source not found.**) to investigate depth dependence.

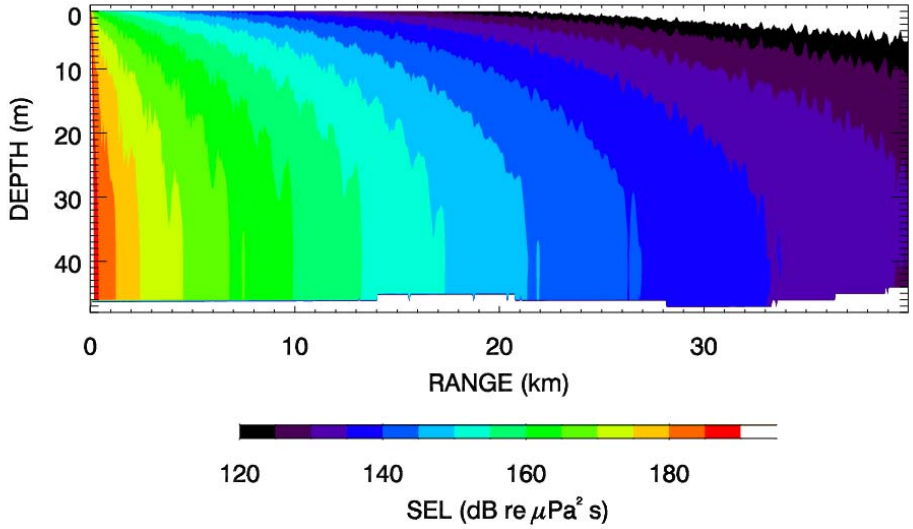


FIGURE 3.12. Modeled endfire SEL versus depth and range.

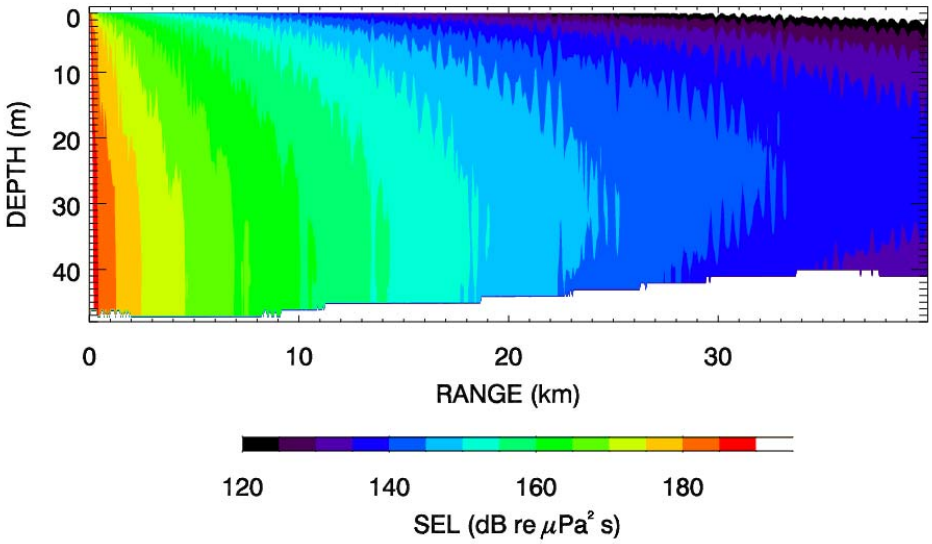


FIGURE 3.13. Modeled broadside SEL versus depth and range.

Sound level increase with depth is strongly apparent for propagation in both the endfire and broadside directions. Interestingly, the depth of maximum level is near the bottom in the endfire direction and above the bottom, at 20-30 m depth in the broadside direction. This behavior is attributed to the difference in dominant frequencies predicted by the model for these two directions. The lower frequency energy, having modes that extend more strongly into the bottom, dominates the endfire model results while higher frequency energy is predicted to dominate the sound field in the broadside direction. High frequency energy propagates mainly as modes in the water column so the depth of sound energy maximum is moved up into the water. The data however suggest that higher frequency energy dominates the sound field in both directions. This means that highest energy levels are likely between mid-depth and the bottom for all directions. Sound levels at 10 m depth are always lower than those at deeper depths. The characteristic of depth variation in the sound field could be important for assessing ranges of potential impact on marine mammals.

## *Model Sensitivity to Source Depth*

An important observation arising from the comparison of modeled and measured sound levels from the source verification test is that the modeled sound levels at close ranges tended to underestimate the measured values. At the closest ranges, less than 200 m, the sound field level is less dependent on the environmental geoacoustic conditions so the mismatch is more likely attributed to either an error in source level. Source level errors could have occurred due to incorrectly-specified source (airgun array) tow depth. To investigate the sensitivity to source level we performed a new model run using source depth of 9 m instead of the 6 m depth (that was measured by a depth sensor during the experiment). The model results of SEL versus range, for the intermediate bottom type, are presented for both source depths and in both endfire and broadside directions in Figure 3.14. The measured data are overplotted in this figure.

The comparison of model results for 6m and 9m source depths indicates that sound levels are moderately dependent on source depth. The 9m source depth model results are approximately 2-3 dB greater than the 6 m results in the endfire direction at all ranges, but are only about 0-2 dB greater in the broadside direction. This analysis indicates that source depth is an important factor for prediction of airgun array noise levels. Reduction of source depth decreases the level of horizontally-emitted sound energy. It does not appear that incorrectly-specified source depth could fully account for mismatch between model results and measurements. Therefore it is likely that the model's source level estimates were low.

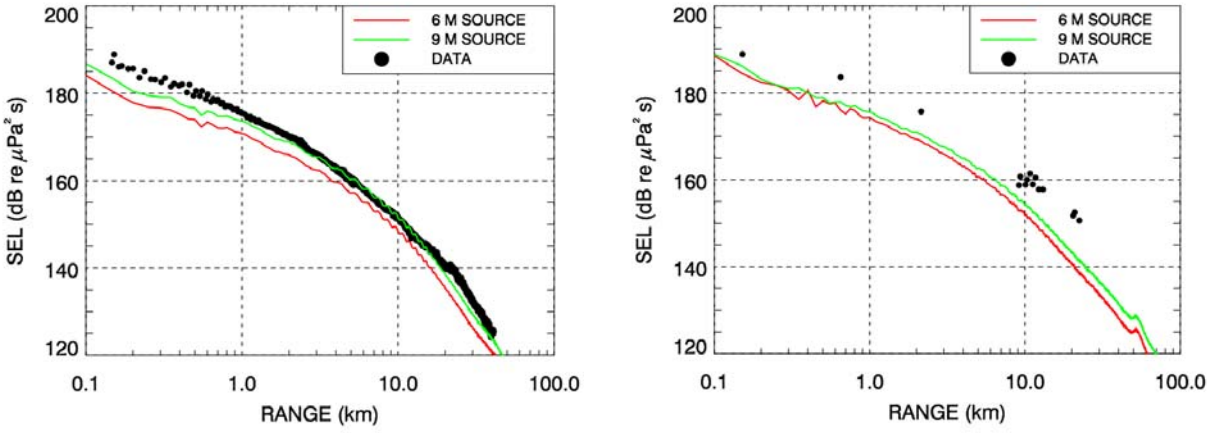


Figure 3.14. Modeled SEL versus range for source depths 6m and 12m, with measured SEL in (a) endfire direction and (b) broadside direction.

## *Summary*

The modeling and measurement programs for ConocoPhillips's 2006 Alaskan Chukchi Seismic Survey provide detailed descriptions of the characteristics of noise generated by the survey's airgun array systems. The noise field at distance from the airgun array is strongly dependent on the shallow water environment, which was shown by both the model predictions and field measurements to effectively trap mid-high frequency sound energy produced by the airguns. The reflectivity of the seabed, defined mainly by sound speeds in the near-seafloor bottom layers, strongly influences the distances at which given sound level thresholds are reached. A model study of sensitivity to bottom reflectivity showed that the range to 120 dB SEL was reached at 32 km over an absorptive bottom and at 48 km over a reflective bottom in the endfire direction. The corresponding distance measured during the source verification tests was 45 km. The modeled ranges in the broadside direction were 54 km and 75 km. Broadside measurements were limited to maximum range 25 km, so no direct comparison can be made. Note the above discussion references SEL and not *rms* levels.

Low frequency energy, below 100 Hz, was rapidly stripped away from the propagating signals with distance. At very short ranges, less than 1 km, only minimal differences in received levels were observed between endfire and broadside directions. This behavior is attributed to the strong contributions of low frequency energy at short distances; airgun array directivity at low frequencies is small. Beyond 1 km, however, higher frequency sounds were observed to have higher relative importance, and directivity therefore increased. At 5 km range the endfire levels were almost 10 dB below the corresponding broadside levels. At 10 km range, where sound frequencies between 100 Hz and 500 Hz dominated the field, the difference was more than 10 dB. The distances to specific sound levels in both directions are presented in Table 3.2. All sound frequencies measured would have been in the sensitive hearing frequency range of bowhead whales. Most sound occurred below 500 Hz, and consequently was below the most sensitive hearing frequency range of belugas. M-weighting for mid-frequency cetaceans reduces the importance of lower-frequency sounds to account for the decreased sensitivity at the low frequencies. It is appropriate for assessing potential impacts on belugas.

A model-based analysis of sound level variation with depth showed that highest sound levels can be expected near the bottom when low frequencies (below 100 Hz) are dominant (this is the case for ranges to 1 km). The depth of maximum sound level moves upward into the water, to between 20 and 30 m depth, at longer ranges where higher frequencies are dominant. Sound levels at 10 m depth, where the 2006 pre-season estimates were made, are expected to be approximately 5 dB below the maximum levels. Future modeling and measurement studies should take into account this depth variation.

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# 4. MONITORING AND MITIGATION METHODS

This chapter describes the marine mammal monitoring and mitigation measures implemented for CPAI's seismic studies in the Chukchi Sea, addressing the requirements specified in the IHAs (Appendices A and B). The section begins with a brief summary of the monitoring tasks relevant to mitigation for marine mammals. A summary of the mitigation measures required by NMFS and USFWS is then presented. The section ends with a description of the vessel-based monitoring and mitigation methods implemented for these surveys and a description of data analysis methods.

## *Monitoring Tasks*

The main purposes of the vessel-based monitoring program were to ensure that the provisions of the IHAs issued to CPAI by NMFS and USFWS were satisfied, effects on marine mammals were minimized, and residual effects on animals were documented. Tasks specific to monitoring are listed below (also see Appendix A):

- Provide qualified MMOs for the source and support vessels throughout the seismic surveys in the Chukchi Sea.
- Visually monitor the occurrence and behavior of marine mammals near the airguns when the airguns are operating and during a sample of the times when they are not.
- Visually monitor the occurrence and behavior of marine mammals near support vessels when underway.
- Use support vessels to conduct visual surveys of areas where airgun sound could have received levels ≥160 dB re 1 μPa $_{rms}$.
- Record (insofar as possible) the effects of the airgun operations and the resulting sounds on marine mammals.
- Use the visual monitoring data as a basis for implementing the required mitigation measures.
- Estimate the number of marine mammals potentially exposed to strong airgun sounds.

## *Safety and Potential Disturbance Radii*

### *Chukchi Sea*--Western Patriot

Under current NMFS guidelines (e.g., NMFS 2000), "safety radii" for marine mammals around airgun arrays are customarily defined as the distances within which received pulse levels are ≥180 dB re 1 $\mu Pa_{rms}$ for cetaceans and ≥190 dB re 1 $\mu Pa_{rms}$ for pinnipeds. The ≥190 dB guideline was also employed by the USFWS for the animals under its jurisdiction (polar bears and walruses) in its IHA issued to CPAI. These safety criteria are based on an assumption that seismic pulses at lower received levels will not injure these animals or impair their hearing abilities, but that higher received levels *might* have some such effects. Marine mammals exposed to ≥160 dB are assumed by NMFS to be potentially subject to behavioral disturbance. However, for certain groups (dolphins, pinnipeds), available data indicate that disturbance is unlikely to occur at this threshold (Moulton and Lawson 2002; Stone 2003, Miller et al. 2005).

In 2006, there was a requirement to implement special mitigation measures if large groups (≥12 individuals) of bowhead or gray whales might be exposed to ≥160 dB (MMS 2006). Monitoring of the 160 dB zone is discussed below in the section on Special Mitigation Measures.

CPAI's IHA applications described the anticipated underwater sound field around the planned 3390 $in^3$ airgun array with guns at a depth of 6 m (20 ft). The anticipated acoustic signature for this array was first computed by CPAI and sound output radii for the array were estimated (Table 4.1A).

Subsequent to submitting its applications, CPAI contracted with JASCO Research Ltd. to model sound source characteristics using a model that incorporated known physical features, e.g. bottom hardness (see Chapter 3). The JASCO implementation of a parabolic equation model was believed by CPAI and NMFS to be superior in these waters because it accounts for effects of bathymetry, water properties, and the geoacoustic properties of seabed layers. The radii predicted by JASCO (Table 4.1B) were based on the worst case model predictions. This model was used by CPAI to estimate sound level isopleths and radii for received rms sound levels between 160 and 190 dB. These predicted distances were multiplied by a safety margin of 1.5 to obtain initial protective marine mammal safety radii (based on the 190 and 180 dB criteria) as well as estimates of "disturbance radii" at 160 dB.

Field measurements of the received airgun sounds as a function of distance and aspect were acquired prior to the beginning of routine seismic data acquisition (Chapter 3). In all cases involving the primary airgun array (2 strings; total of 16 airguns), measured radii were greater than modeled radii (Table 4.1C, D). The empirical measurements of the 180 and 190 dB (rms) radii, as presented by JASCO in Chapter 3 were thus adopted as safety radii for the survey.

More extensive analysis of the field measurements was completed after the field season, as described in Chapter 3. Those analyses resulted in some refinements of the various radii (Table 4.1E, F). The refined values were not available for use by the MMOs in the field. However, the refined estimates have been used in Chapter 5 to estimate the numbers of marine mammals exposed to various sound levels.

Airguns operating underwater do not produce strong sounds in air. Accordingly, no shut downs or power downs were implemented for marine mammals on ice.

TABLE 4.1. Comparison of various predictions and measurements of the 190, 180, 170, and 160 dB (rms) distances (in km) for sound pulses from the 2-string airgun array deployed from the *Western Patriot* in the Chukchi Sea, Alaska, 2006.

| Received Level (dB re 1 µPa) | A. CPAI Modeling | B. JASCO Modeling | C. Preliminary Measured Radii (endfire) | D. Preliminary Measured Radii (broadside) | E. Final Measured Radii (endfire) | F. Final Measured Radii (broadside) |
|---|---|---|---|---|---|---|
| 190 | 0.15 | 0.23 | 0.5 | 0.7 | 0.51 | 0.52 |
| 180 | 0.25 | 0.88 | 1.1 | 1.75 | 1.11 | 1.63 |
| 170 | N/A | 2.05 | 2.55 | 6 | 2.39 | 4.69 |
| 160 | 0.7 | 4.59 | 6 | 12.5 | 5.09 | 11.43 |

## *Mitigation Measures as Implemented*

The primary mitigation measures that were implemented during the seismic activities in the Chukchi Sea included ramp up, power down, and shut down of the airguns. These measures are standard

procedures during seismic cruises and are described in detail in Appendix E. Mitigation also included those measures specifically identified in the IHA (Appendix A) as indicated below.

### *Standard Mitigation Measures*

Standard mitigation measures implemented during the study included the following:

1. Developed and implemented safety radii for the seismic activities based on preliminary results of the empirical sound measurement studies using the endfire radii reported by JASCO.
2. Power-down or shut-down procedures were implemented when a marine mammal was sighted within or approaching the applicable safety radius while the airguns were operating.
3. A change in vessel course and/or speed alteration was identified as a potential mitigation measure if a marine mammal was detected outside the safety radius and, based on its position and motion relative to the ship track, was judged likely to enter the safety radius. In practice, this measure was not implemented because the *Western Patriot* was unable to maneuver while towing the airguns and streamers.
4. A ramp-up procedure was implemented whenever operation of the airguns was initiated.
5. In order for seismic operations to start up during day or night, the full applicable safety radius must have been visible for at least 30 min.

The specific procedures applied during power downs, shut downs, and ramp ups are described in Appendix E. Briefly, a ***power down*** as implemented aboard the *Western Patriot* involved reducing the number of operating airguns from the full array of 16 airguns to one airgun when a marine mammal was observed approaching or was seen within the safety radius. Power down also occurred when the *Western Patriot* was between seismic survey lines to reduce the area of ensonification. The 190 and 180 dB radii around the much-reduced source operated during a power down were 145 m and 154 m. A ***shut down*** involved suspending operation of all airguns. A shut down was sometimes implemented when a mammal was first sighted within or approaching its safety radius. At other times the airgun array was first powered down, and was later fully shut down if the mammal approached the safety radius around the small source that operated during power downs. A ***ramp-up*** involved a gradual increase in the number of airguns operating, with the number of operating guns generally being doubled every 5 min until the full array was operating.

### *Special Mitigation Measures as Required by NMFS*

In addition to the standard safety radii based on the 190 and 180 dB (rms) distances for pinnipeds and cetaceans, respectively, NMFS (in the IHA) required CPAI to monitor the 160 dB radius during all seismic activities.

The 160 dB radius extended approximately 11.4 km from the airgun source on the *Western Patriot* and was generally monitored by MMOs onboard the *Torsvik*, or by MMOs onboard the *Gulf Provider* during periods when it served as the chase boat for the *Western Patriot*. MMOs onboard the *Torsvik*, and occasionally the *Gulf Provider* when it served as the *Western Patriot's* chase vessel, searched the area ~6-8 km ahead of the *Western Patriot* within the 160 dB zone for marine mammals. Mitigation (i.e., power down or shut down of the airgun array) was to be implemented if a group of 12 or more bowhead or gray whales entered the 160 dB zone. No large groups of baleen whales were observed within the 160 dB zone and no power downs or shut downs were necessary for groups of cetaceans.

## *Visual Monitoring Methods*

Visual monitoring methods were designed to meet the requirements identified in the IHA (see above and Appendices A and B). The primary purposes of MMOs aboard the seismic source and support vessels were as follows: ***(1)*** conduct monitoring and implement mitigation measures to avoid or minimize exposure of cetaceans to airgun sounds with received levels >180 dB (rms), or of pinnipeds to >190 dB (rms). ***(2)*** conduct monitoring and implement mitigation measures to avoid or minimize exposure of groups of 12 or more bowhead or gray whales to airgun sounds with received levels >160 dB (rms). ***(3)*** document numbers of marine mammals present, any reactions of marine mammals to seismic activities, and whether there was any possible effect on accessibility of marine mammals to subsistence hunters in Alaska. Results of the monitoring effort are presented in Chapter 5.

The visual monitoring methods that were implemented during CPAI's seismic exploration were very similar to those used during various previous seismic cruises conducted under IHAs since 2003 (e.g., Holst et al. 2005a,b; Ireland et al. 2005). The standard visual observation methods are described in Appendix E.

In summary, during the seismic surveys in the Chukchi Sea, at least one MMO onboard the source vessel (*Western Patriot*) maintained a visual watch for marine mammals during all daylight hours while seismic surveys were underway. During the surveys, two visual observers were on duty for 31% of the time watches were conducted on the *Western Patriot*. Observers focused their search effort forward and to the side of the vessel but also searched aft of the vessel while it was underway. Watches were conducted with the naked eye, Fujinon 7 × 50 reticle binoculars, and Cannon 18 × 50 binoculars. MMOs instructed seismic operators to power down or shut down the airguns if marine mammals were sighted near or about to enter the appropriate safety radii.

MMOs onboard the chase vessels conducted watches similar to those of MMOs onboard the *Western Patriot*. This has not been standard practice during seismic surveys in Alaska. Typically, MMOs have been stationed only on the source vessel. The chase vessels for the *Western Patriot* generally traveled ~6–8 km ahead of the *Western Patriot* to monitor the 160 dB radius, which JASCO found to extend ~12.5 km from the *Western Patriot* sound source. MMOs onboard the chase vessels were thus prepared to notify MMOs onboard the *Western Patriot* if groups of bowheads or gray whales (or bowhead cow/calf pairs) were sighted within the 160 dB radius, allowing the *Western Patriot* to implement the appropriate mitigation. Appendix E provides further details regarding visual monitoring methods.

## *Analyses*

***Categorization of Data***.—Observer effort and marine mammal sightings were divided into several analysis categories related to vessel and seismic activity. The categories were similar to those used during various other recent seismic studies conducted under IHAs (e.g., Haley and Koski 2004; MacLean and Koski 2005; Smultea et al. 2005; Holst et al. 2005a,b; Ireland et al. 2005). These categories are defined briefly below, with a more detailed description provided in Appendix E.

In general, data were categorized as "seismic" or "non-seismic". "Seismic" included all data collected from the source vessel (*Western Patriot*) while the airguns were operating. Non-seismic included all data obtained before the airguns were activated (pre-seismic) or >1 or >2 h (for pinnipeds and cetaceans, respectively) after the airguns were deactivated. Data collected during post-seismic periods from 3 min to 1 h (for pinnipeds) or 2 h (for cetaceans) after cessation of seismic activity were considered

either "recently exposed" (3–30 min) or "potentially exposed" (30 min to 1 or 2 h) to seismic sound levels, and were excluded from analyses. Thus, the post-seismic data (3 min to 1 or 2 h after cessation of seismic) were not included in either the "seismic" or "non-seismic" categories. The 3 min cutpoint was considered appropriate because of the relatively slow speed during seismic operations (~4 kt or 7.4 km/h, average). The 1 and 2 h cutoff periods correspond to the time required to transit to an area in which the received sound level would not be likely to have much (if any) effect on the distributions of pinnipeds and cetaceans, respectively. The chosen sound levels were comparable to those used in other recent seismic cruises (Haley and Koski 2004; MacLean and Koski 2005; Holst et al. 2005a; Ireland et al. 2005). Periods of time during which other vessels were sighted within 1 km of the *Patriot* (for pinnipeds) and 5 km of the *Patriot* (for cetaceans) were also excluded. At the time of publishing it was not possible to calculate the specific distance between the chase vessel and *Patriot* beyond the usual operating distance of ~4.3 nm or ~8 km apart. At this distance it is unlikely that the distribution of pinnipeds would have been affected by the seismic noise generated by the *Patriot*; thus all pinniped sightings from the chase vessels are included as "non-seismic". The distance at which the distribution of cetaceans may have been affected by the *Patriot* was greater; therefore we did not classify cetacean sightings from the chase vessels as either seismic or non-seismic.

This categorization system was designed primarily to distinguish potential differences in behavior and distribution of marine mammals with and without seismic surveys. The rate of recovery toward "normal" during the post-seismic period is uncertain. Marine mammal responses to seismic sound likely diminish with time after the cessation of seismic activity. The end of the post-seismic period was defined as a time long enough after cessation of airgun activity to ensure that any carry-over effects of exposure to sounds from the airguns would have waned to zero or near-zero. The reasoning behind these categories was explained in MacLean and Koski (2005) and Smultea et al. (2005) and is discussed in Appendix E.

***Line Transect Estimation of Densities***.—Marine mammal sightings during the "seismic" and "non-seismic" periods were used to calculate sighting rates (#/km). Sighting rates were then used to calculate the corresponding densities (#/km$^2$) of marine mammals near the survey and chase ships during seismic and non-seismic periods. Density calculations were based on line-transect principles (Buckland et al. 2001). Because of assumptions associated with line-transect surveys [sightability, $f(0)$, $g(0)$, etc.], only "useable" effort and sightings were included in density calculations. Effort and sightings were defined as "useable" when made under the following conditions: daylight periods both within the seismic survey area and during transit to and from that area, excluding

- periods 3 min to 1 or 2 h after the airguns were turned off (post-seismic), or
- when ship speed was <3.7 km/h (2 kt), or
- with seriously impaired sightability. (This included all nighttime observations, and daytime periods with one or more of the following: visibility <3.5 km, Beaufort sea state (Bf) >5 (Bf >2 for porpoises; see Appendix Table G.2 for sightings of cetaceans and pinnipeds vs. sea state), or >60º of severe glare between 90º left and 90º right of the bow.)

When calculating sighting rates and densities in non-seismic periods, only the observations in the Chukchi Sea were considered, i.e., observations during transit through the Bering Sea were excluded. All observations included from the chase vessel were sightings made while the chase vessel was working within ~8 km of the *Patriot*. The most meaningful comparison of sightings between seismic and non-seismic periods would be to compare seismic and non-seismic observations from the *Patriot*, exclusively. We caution that this is not statistically viable due to the few (11) sightings during non-seismic periods. Pinnipeds hauled out on the ice were encountered in the Chukchi Sea; these sightings were considered

"useable" for analyses.

Correction factors for missed animals,$f(0)$, or sightability, were calculated from this project's sighting data (Appendices E,I). The correction factors for $g(0)$, or trackline sighting probability, were not derived directly from the survey data, but were calculated for gray, bowhead, and unidentified whales, Pacific walruses, bearded, ringed, and unidentified seals, as well as unidentified pinnipeds (see Appendix E) from other related studies, as used by Koski et al. (1998), LGL (2005a), and LGL (2006). This was necessary because of the inability to assess, $g(0)$, during a study of this type.

Densities estimated from non-seismic observations were used to estimate the numbers of animals that presumably would have been present in the absence of seismic activities. Densities during seismic periods were used to estimate the numbers of animals present near the seismic operation and exposed to various sound levels. The difference between the two estimates could be taken as an estimate of the number of animals that moved in response to the operating seismic vessel, or that changed their behavior sufficiently to affect their detectability to visual observers. Further details on the line transect methodology used during the survey are provided in Appendix E.

***Estimating Numbers Potentially Affected***.—For purposes of the IHA, NMFS assumes that any marine mammal that might have been exposed to airgun pulses with received sound levels ≥160 dB re 1 $\mu Pa_{rms}$ may have been disturbed. "Disturbance" includes a variety of effects, including subtle changes in behavior, more conspicuous changes in activities, and displacement. When calculating the number of mammals potentially affected, we used the measured 160 dB radii with some adjustments based on JASCO's final measurements of the broadside sound level radii (Table 4.1).

We estimated the numbers of individual marine mammals that may have been exposed to sound levels ≥160 dB re 1 $\mu Pa_{rms.}$ We also calculated the potential number of total exposures of individuals (if each did not react in an avoidance manner) to sound levels ≥160 dB, given the overlap of sound levels from the seismic tracklines:

The "individual" animal exposure calculation involved multiplying the following three values for each airgun configuration in use: (***A***) km of seismic survey; (***B***) width of area assumed to be ensonified to ≥160 dB (2 × 160 dB radius); and (***C***) densities of marine mammals estimated from this study (Appendix I). The areas ensonified to ≥160 dB on more than one occasion, due to overlapping tracklines, were counted only once.

The total "exposures" calculation involved multiplying the same three values, but areas of water ensonified on more than one occasion, due to overlapping or adjacent tracklines, were counted in the area calculation as many times as they were ensonified. The area of water considered ensonified in this calculation is therefore significantly larger than in the first calculation. From this value, we calculated the average number of exposures per individual. During the Chukchi Sea surveys by the *Western Patriot,* many of the tracklines were in close proximity to one another in comparison with the 160 dB distance, leading to much overlap of the areas ensonified to ≥160 dB. In this situation, the two approaches lead to very different values for the ensonified area, and the estimated number of individuals exposed is much lower than the estimated number of exposures.

# 5. RESULTS OF MARINE MAMMAL MONITORING PROGRAM[3]

## INTRODUCTION

This chapter describes the results of CPAI's 2006 marine mammal monitoring program. In addition, the numbers of marine mammals potentially affected during project operations within the study area are estimated. The study area, for the purposes of marine mammal data analyses, was the actual seismic survey area and transit areas within the Chukchi Sea, representing ~5.6% of the total lease sale area (see Fig. 2.1).

The marine mammals known to occur along the cruise trackline across the Chukchi Sea belong to four taxonomic groups: odontocetes (toothed whales, including the beluga whale), mysticetes (baleen whales), pinnipeds (seals and walruses), and ursids (polar bear). Nine cetacean species and five species of pinnipeds are known to occur in the survey area, along with the polar bear. Of the total 15 species, two (both cetaceans) are listed under the U.S. Endangered Species Act (ESA) as endangered: the bowhead and fin whale. Appendix F summarizes the abundance, habitat, and conservation status of the marine mammal species likely to occur in the cruise area.

## CHUKCHI SEA MONITORING

### *Monitoring Effort and Marine Mammal Encounter Results*

This section summarizes the visual monitoring effort and sightings from the *Patriot* and the "chase vessel" during the Chukchi Sea seismic survey from 14 July to 18 Oct. 2006. The chase vessel data are a combination of the MMO sightings data from the *Torsvik* (14 Jul.–8 Aug.; 19 Aug.–1 Sept.; 11 Sept.–18 Sept.; 28 Sept.–10 Oct.), and the *Gulf Provider*(14 Aug.–18 Aug.; 2 Sept.–10 Sept.; 19 Sept.–27 Sept.; 11 Oct.–14 Oct.) which both served as the chase vessel for the *Patriot* at alternating times. Chase vessel sightings during transits were not included in this analysis. All sightings from the chase vessel considered in analysis were made when the chase vessel was working within ~8 km of the *Patriot*. Summaries of results of visual monitoring are presented here, with more detailed data presented in Appendices G and H, including survey effort in both kilometers and hours. A general summary of effort and sightings is shown in Table 5.1 and depicted in detail in Appendix Table G.4. Marine mammals observed during transits outside the study area are summarized in Appendix Table G.3.

Seismic survey activities by the *Patriot* occurred along 16,028 km of trackline over a total of 1965 h (Fig. 2.1; Appendix Table G.2); this was ~5.6% of the total lease sale area (137,594 $km^2$ or 34 million acres). Survey operations were conducted in an offshore area with a radius of ~165 km (89 nm). In total, 30,406 km and 3076 h of visual observations were conducted within the Chukchi Sea study area, including 17,862 km and 1965 h of observation from the *Patriot* and 12,544 km and 1111 h from the chase vessel. "Useable" survey conditions occurred during 40% (in km; 38% in h) of the total visual effort (Appendix Table G.2). "Useable" effort excluded periods 3 min to 1 h (for pinnipeds) or 2 h (for cetaceans) after the airguns were turned off, poor visibility conditions (visibility <3.5 km or extensive glare), and Bf >5. Sightings were highly influenced by Bf; sightability dropped significantly for cetaceans at Bf 5 and for pinnipeds at Bf 4 (Appendix G.1). Bf 5 was used for both cetaceans and pinnipeds, as is the standard in most marine mammal sighting reports. Periods of time during which other vessels were sighted

[3] By Darren Ireland, Heather Patterson, Meaghan Jankowski, Andrea Hunter, Beth Haley, and Bob Rodrigues.

TABLE 5.1. Detection rates for sightings from the *Patriot* (17 Jul.−14 Oct. 2006) and chase vessel (14 Jul.−14 Oct. 2006) during the Chukchi Sea cruise.

| | Non-Seismic | | | Post-Seismic | | | Seismic | | | *Total* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Effort Type** | **No. of Detections** | **Effort (km)** | **Detection Rate (No./1000 km)** | **No. of Detections** | **Effort (km)** | **Detection Rate (No./1000 km)** | **No. of Detections** | **Effort (km)** | **Detection Rate (No./1000 km)** | **No. of Detections** | **Effort (km)** | **Detection Rate (No./1000 km)** |
| ***A. Patriot*** | | | | | | | | | | | | |
| **Useable[a]** | | | | | | | | | | | | |
| Cetaceans | 8 | 890 | 9.0 | 0 | 0 | 0 | 2 | 4800 | 0.4 | **10** | **5690** | **1.8** |
| Pinnipeds in water | 3 | 890 | 3.4 | 0 | 0 | 0 | 81 | 4800 | 16.9 | **84** | **5690** | **14.8** |
| Pacific Walrus in water | 2 | 890 | 2.2 | 0 | 0 | 0 | 11 | 4800 | 2.3 | **13** | **5690** | **2.3** |
| Pinnipeds on ice | 0 | 890 | 0.0 | 0 | 0 | 0 | 0 | 4800 | 0.0 | **0** | **5690** | **0.0** |
| Pacific Walrus on ice | 0 | 890 | 0.0 | 0 | 0 | 0 | 0 | 4800 | 0.0 | **0** | **5690** | **0.0** |
| *Total All Pinnipeds* | *3* | *890* | *3.4* | *0* | *0* | *0* | *81* | *4800* | *16.9* | ***84*** | ***5690*** | ***14.8*** |
| *Total Unidentified Pinnipeds* | *0* | *890* | *0.0* | *0* | *0* | *0* | *5* | *4800* | *1.0* | ***5*** | ***5690*** | ***0.9*** |
| *Total All Pacific Walrus* | *2* | *890* | *2.2* | *0* | *0* | *0* | *11* | *4800* | *2.3* | ***13*** | ***5690*** | ***2.3*** |
| *Total Seals* | *1* | *890* | *1.1* | *0* | *0* | *0* | *65* | *4800* | *13.5* | ***66*** | ***5690*** | ***11.6*** |
| **Non-Useable[b]** | | | | | | | | | | | | |
| Cetaceans | 3 | 854 | 3.5 | 0 | 90 | 0.0 | 9 | 11228 | 0.8 | **12** | **12172** | **1.0** |
| Pinnipeds in water | 1 | 854 | 1.2 | 1 | 90 | 11.1 | 56 | 11228 | 5.0 | **58** | **12172** | **4.8** |
| Pacific Walrus in water | 0 | 854 | 0.0 | 0 | 90 | 0.0 | 10 | 11228 | 0.9 | **10** | **12172** | **0.8** |
| Pinnipeds on ice | 0 | 854 | 0.0 | 0 | 90 | 0.0 | 0 | 11228 | 0.0 | **0** | **12172** | **0.0** |
| Pacific Walrus on ice | 0 | 854 | 0.0 | 0 | 90 | 0.0 | 0 | 11228 | 0.0 | **0** | **12172** | **0.0** |
| *Total All Pinnipeds* | *1* | *854* | *1.2* | *1* | *90* | *11.1* | *56* | *11228* | *5.0* | ***58*** | ***12172*** | ***4.8*** |
| *Total Unidentified Pinnipeds* | *0* | *854* | *0.0* | *0* | *90* | *0.0* | *1* | *11228* | *0.1* | ***1*** | ***12172*** | ***0.1*** |
| *Total All Pacific Walrus* | *0* | *854* | *0.0* | *0* | *90* | *0.0* | *10* | *11228* | *0.9* | ***10*** | ***12172*** | ***0.8*** |
| *Total Seals* | *1* | *854* | *1.2* | *1* | *90* | *11.1* | *45* | *11228* | *4.0* | ***47*** | ***12172*** | ***3.9*** |
| ***Patriot Totals*** | | | | | | | | | | | | |
| ***Cetaceans*** | **11** | **1744** | **6.3** | **0** | **90** | **0.0** | **11** | **16028** | **0.7** | **22** | **17862** | **1.2** |
| ***Pinnipeds*** | **4** | **1744** | **2.3** | **1** | **90** | **11.1** | **137** | **16028** | **8.5** | **142** | **17862** | **7.9** |
| *Unidentified Pinnipeds* | *0* | *1744* | *0.0* | *0* | *90* | *0.0* | *6* | *16028* | *0.4* | *6* | *17862* | *0.3* |
| *Pacific Walrus* | *2* | *1744* | *1.1* | *0* | *90* | *0.0* | *21* | *16028* | *1.3* | *23* | *17862* | *1.3* |
| *Seals* | *2* | *1744* | *1.1* | *1* | *90* | *11.1* | *110* | *16028* | *6.9* | *113* | *17862* | *6.3* |
| ***B. Chase Vessel*** | | | | | | | | | | | | |
| **Useable[a]** | | | | | | | | | | | | |
| Pinnipeds in water | 652 | 6482 | 100.6 | N/A | N/A | N/A | N/A | N/A | N/A | **652** | **6482** | **100.6** |
| Pacific Walrus in water | 45 | 6482 | 6.9 | N/A | N/A | N/A | N/A | N/A | N/A | **45** | **6482** | **6.9** |
| Pinnipeds on ice | 2 | 6482 | 0.3 | N/A | N/A | N/A | N/A | N/A | N/A | **2** | **6482** | **0.3** |
| Pacific Walrus on ice | 2 | 6482 | 0.3 | N/A | N/A | N/A | N/A | N/A | N/A | **2** | **6482** | **0.3** |
| *Total All Pinnipeds* | *654* | *6482* | *100.9* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | ***654*** | ***6482*** | ***100.9*** |
| *Total Unidentified Pinnipeds* | *264* | *6482* | *40.7* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | ***264*** | ***6482*** | ***40.7*** |
| *Total All Pacific Walrus* | *47* | *6482* | *7.3* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | ***47*** | ***6482*** | ***7.3*** |
| *Total Seals* | *343* | *6482* | *52.9* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | ***343*** | ***6482*** | ***52.9*** |
| **Non-Useable[b]** | | | | | | | | | | | | |
| Pinnipeds in water | 175 | 6063 | 28.9 | N/A | N/A | N/A | N/A | N/A | N/A | **175** | **6063** | **28.9** |
| Pacific Walrus in water | 17 | 6063 | 2.8 | N/A | N/A | N/A | N/A | N/A | N/A | **17** | **6063** | **2.8** |
| Pinnipeds on ice | 0 | 6063 | 0.0 | N/A | N/A | N/A | N/A | N/A | N/A | **0** | **6063** | **0.0** |
| Pacific Walrus on ice | 0 | 6063 | 0.0 | N/A | N/A | N/A | N/A | N/A | N/A | **0** | **6063** | **0.0** |
| *Total All Pinnipeds* | *175* | *6063* | *28.9* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | ***175*** | ***6063*** | ***28.9*** |
| *Total Unidentified Pinnipeds* | *1* | *6063* | *0.2* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | ***1*** | ***6063*** | ***0.2*** |
| *Total All Pacific Walrus* | *17* | *6063* | *2.8* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | ***17*** | ***6063*** | ***2.8*** |
| *Total Seals* | *157* | *6063* | *25.9* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | ***157*** | ***6063*** | ***25.9*** |
| ***Chase Vessel Totals*** | | | | | | | | | | | | |
| ***Pinnipeds*** | ***829*** | ***12544*** | ***66.1*** | ***N/A*** | ***N/A*** | ***N/A*** | ***N/A*** | ***N/A*** | ***N/A*** | ***829*** | ***12544*** | ***66.1*** |
| *Unidentified Pinnipeds* | *265* | *12544* | *21.1* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | ***265*** | ***12544*** | ***21.1*** |
| *Pacific Walrus* | *64* | *12544* | *5.1* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | ***64*** | ***12544*** | ***5.1*** |
| *Seals* | *500* | *12544* | *39.9* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | *N/A* | ***500*** | ***12544*** | ***39.9*** |
| **Overall Totals for Both Vessels** | | | | | | | | | | | | |
| **Cetaceans[c]** | **11** | **1744** | **6.3** | **0** | **90** | **0** | **9** | **16028** | **0.6** | **22** | **17862** | **1.2** |
| **Pinnipeds** | **833** | **14288** | **58.3** | **1** | **90** | **11.1** | **137** | **16028** | **8.5** | **971** | **30406** | **31.9** |
| Unidentified Pinnipeds | 265 | 14288 | 18.5 | 0 | 90 | 0 | 21 | 16028 | 1.3 | 271 | 30406 | 8.9 |
| Pacific Walrus | 66 | 14288 | 4.6 | 0 | 90 | 0 | 0 | 16028 | 0 | 87 | 30406 | 2.9 |
| Seals | 502 | 14288 | 35.1 | 1 | 90 | 11.1 | 0 | 16028 | 0 | 613 | 30406 | 20.2 |

Note: N/A means not applicable.
[a] Useable sightings are those made during useable daylight periods of visual observation, as defined in *Acronyms and Abbreviations.*
[b] Includes the "Post-Seismic" category.
[c] Includes only sightings from the *Patriot*

within 1 km of the *Patriot* (for pinnipeds) and 5 km of the *Patriot* (for cetaceans) were also excluded. At the time of publishing it was not possible to calculate the distance between the chase vessel and *Patriot* beyond the usual operating distance of ~6 - 8 km. At this distance it is unlikely that the distribution of pinnipeds would have been affected by the seismic noise generated by the *Patriot*, thus all pinniped

sightings from the chase vessel are included as 'non-seismic'. The distance at which the distribution of cetaceans may have been affected by seismic operations on the *Patriot* was likely ~11 km, the range within which the chase vessel was working and marine mammal data was collected. Therefore we did not classify cetacean sightings from the chase vessel as either seismic or non-seismic. As such, cetacean sightings from the chase vessel are described, but *not* included, in any analyses or calculations. It is important to caution that the useable data from the *Patriot*, which would offer the most meaningful, direct comparison of seismic vs non-seismic sightings, includes too few non-seismic data (11 sightings; Tables 5.1, 5.2) for a statistically viable comparison with seismic data (83 sightings). The project provided data on the summer occurrence, distribution, and abundance of marine mammals in the Chukchi Sea, an area where few systematic survey data had previously been collected.

## *Visual Survey Effort*

Survey effort from the *Patriot* and chase vessel, in km and h, subdivided by seismic activity and Beaufort wind force, is summarized in Appendix Table G.3.

***Patriot***.—During 17,862 km of *Patriot* operations, 5690 km of useable visual observations were made (Appendix Table G.2). MMOs observed almost exclusively from the bridge (99.8% of watch time, eyeheight 10.8 m), with the remaining observations conducted from the flying bridge or stern (0.1% each). Of the 1965 h and 17,862 km of visual observation effort, 59.5 h and 548 km (3%) occurred during nighttime ramp up and the preceding half hour before the airguns were on. One observer was on visual watch aboard the *Patriot* during 1503 h (13,659 km), with at least two observers on watch during the remaining 462 h (4203 km).

***Chase vessel***.—Within the Chukchi Sea, the chase vessel covered a distance of 12,544 km, with useable visual observations occurring during 6481 km (>50%; Appendix Table G.2). All visual observations from the chase vessel were made during daytime from the bridge of the *Torsvik* (eye height 7.7 m ASL) or the *Gulf Provider* (eye height 9 m ASL). One observer was on visual watch aboard the chase vessel during 897 h (9788 km), with at least two observers on watch during the remaining 214 h (2756 km).

Beaufort Wind Force (sea state) during observations aboard the *Patriot* and chase vessel ranged from 0 to 10 within the Chukchi Sea, with 0.7% (in h) of the observation effort during conditions of Bf = 0 (Appendix Table G.2). Most (70%) of the 3076 h of observation effort occurred with Beaufort Force 3 to 5 (wind speed 7–21 kt or 13–39 km/h). This is typical for the summer in the study region (Pilot Chart, date unkn.).

## *Visual Sightings of Marine Mammals and Other Vessels*

***Numbers of Marine Mammals Seen***.—An estimated 1189 individual marine mammals were seen in 1034 groups through the Chukchi Sea study area (Table 5.2). Ten different marine mammal species were identified during the ~3 month observation period. Pinnipeds were far more abundant than cetaceans with ringed seal being the most commonly identified species ($n$ = 397 individuals in 359 groups), followed by Pacific walrus ($n$ = 137 in 87 groups; Table 5.3). Bearded and spotted seals were also observed frequently within the project area. Only one ribbon seal was observed during the study period, which was not unusual given their historic use of habitat in offshore pack ice through the Bering and southern Chukchi seas. There were many sightings of unidentified seals ($n$ = 436 individuals in 398 groups); most of these were likely ringed seals, given the visual monitoring results and the known occurrence of this species throughout the study area. The unidentified seals moved too rapidly or were too far away for the observer to make a positive identification.

TABLE 5.2. Numbers of sightings and of individual marine mammals, both (A) total, and (B) useable, observed in the study area from the *Patriot* (17 Jul.−14 Oct. 2006) and from the chase vessel (14 Jul.−14 Oct. 2006), during the Chukchi Sea cruise.

| | *Chase Vessel* | | *Patriot* | | | | | | | | *Total* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Non-Seismic | | Non-Seismic | | Post-Seismic | | Seismic | | *Patriot Total* | | | |
| Species | Sightings | Indiv. | Sightings | Indiv. | Sightings | Indiv. | Sightings | Indiv. | Sightings | Indiv. | Sightings | Indiv. |
| ***A. All Sightings*** | | | | | | | | | | | | |
| **Cetaceans** | | | | | | | | | | | | |
| Unidentified Whale | 8 | 8 | 1 | 1 | 0 | 0 | 4 | 4 | *5* | *5* | **18** | **18** |
| **Odontocetes** | | | | | | | | | | | | |
| Harbor Porpoise | 10 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | *0* | *0* | **10** | **13** |
| Unidentified dolphin | 4 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | *0* | *0* | **4** | **5** |
| Beluga Whale | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 2 | *2* | *2* | **5** | **5** |
| **Mysticetes** | | | | | | | | | | | | |
| Bowhead Whale | 11 | 14 | 1 | 1 | 0 | 0 | 3 | 3 | *4* | *4* | **19** | **22** |
| Gray Whale | 3 | 15 | 2 | 4 | 0 | 0 | 2 | 3 | *4* | *7* | **11** | **29** |
| Minke Whale | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | *0* | *0* | **2** | **2** |
| Unidentified Mysticete Whale | 1 | 1 | 7 | 7 | 0 | 0 | 0 | 0 | *7* | *7* | **15** | **15** |
| ***Total Cetaceans*** | ***40*** | ***59*** | ***11*** | ***13*** | ***0*** | ***0*** | ***11*** | ***12*** | ***22*** | ***25*** | **84** | **109** |
| **Pinnipeds in Water** | | | | | | | | | | | | |
| Unidentified Pinniped | 2 | 2 | 0 | 0 | 0 | 0 | 6 | 6 | *6* | *6* | **14** | **14** |
| **Phocids** | | | | | | | | | | | | |
| Bearded Seal | 56 | 56 | 0 | 0 | 0 | 0 | 10 | 13 | *10* | *13* | **76** | **82** |
| Ribbon Seal | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | *0* | *0* | **1** | **1** |
| Ringed Seal | 342 | 380 | 0 | 0 | 0 | 0 | 17 | 17 | *17* | *17* | **376** | **414** |
| Spotted Seal | 43 | 45 | 0 | 0 | 0 | 0 | 9 | 10 | *9* | *10* | **61** | **65** |
| Unidentified Seal | 321 | 356 | 2 | 2 | 1 | 1 | 74 | 77 | *77* | *80* | **475** | **516** |
| **Odobenids** | | | | | | | | | | | | |
| Pacific Walrus | 62 | 102 | 2 | 2 | 0 | 0 | 21 | 30 | *23* | *32* | **108** | **166** |
| **Pinnipeds on Ice** | | | | | | | | | | | | |
| Pacific Walrus | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | *0* | *0* | **2** | **3** |
| ***Total Pinnipeds*** | ***829*** | ***945*** | ***4*** | ***4*** | ***1*** | ***1*** | ***137*** | ***153*** | ***142*** | ***158*** | **1113** | **1261** |
| *Total Unidentified Pinnipeds* | *2* | *2* | *0* | *0* | *0* | *0* | *6* | *6* | *6* | *6* | **14** | **14** |
| *Total Pacific Walrus* | *64* | *105* | *2* | *2* | *0* | *0* | *21* | *30* | *23* | *32* | **110** | **169** |
| *Total Seals* | *763* | *838* | *2* | *2* | *1* | *1* | *110* | *117* | *113* | *120* | **989** | **1078** |
| ***B. Useable[a] Sightings*** | | | | | | | | | | | | |
| **Cetaceans** | | | | | | | | | | | | |
| **Mysticetes** | | | | | | | | | | | | |
| Bowhead Whale | N/A | N/A | 1 | 1 | 0 | 0 | 2 | 2 | *3* | *3* | **6** | **6** |
| Gray Whale | N/A | N/A | 2 | 4 | 0 | 0 | 0 | 0 | *2* | *4* | **4** | **8** |
| Minke Whale | N/A | N/A | 0 | 0 | 0 | 0 | 0 | 0 | *0* | *0* | **0** | **0** |
| Unidentified Mysticete Whale | N/A | N/A | 5 | 5 | 0 | 0 | 0 | 0 | *5* | *5* | **10** | **10** |
| ***Total Cetaceans*** | ***N/A*** | ***N/A*** | ***8*** | ***10*** | ***0*** | ***0*** | ***2*** | ***2*** | ***10*** | ***12*** | **20** | **24** |
| **Pinnipeds in Water** | | | | | | | | | | | | |
| Unidentified Pinniped | 1 | 1 | 0 | 0 | 0 | 0 | 5 | 5 | *5* | *5* | **11** | **11** |
| **Phocids** | | | | | | | | | | | | |
| Bearded Seal | 44 | 44 | 0 | 0 | 0 | 0 | 7 | 10 | *7* | *10* | **58** | **64** |
| Ringed Seal | 266 | 301 | 0 | 0 | 0 | 0 | 8 | 8 | *8* | *8* | **282** | **317** |
| Spotted Seal | 33 | 34 | 0 | 0 | 0 | 0 | 6 | 7 | *6* | *7* | **45** | **48** |
| Unidentified Seal | 263 | 295 | 1 | 1 | 0 | 0 | 44 | 45 | *45* | *46* | **353** | **387** |
| **Odobenids** | | | | | | | | | | | | |
| Pacific Walrus | 45 | 79 | 2 | 2 | 0 | 0 | 11 | 16 | *13* | *18* | **71** | **115** |
| **Pinnipeds on Ice** | | | | | | | | | | | | |
| Pacific Walrus | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | *0* | *0* | **2** | **3** |
| ***Total Pinnipeds*** | ***654*** | ***757*** | ***3*** | ***3*** | ***0*** | ***0*** | ***81*** | ***91*** | ***84*** | ***94*** | **822** | **945** |
| *Total Unidentified Pinnipeds* | *1* | *1* | *0* | *0* | *0* | *0* | *5* | *5* | *5* | *5* | **11** | **11** |
| *Total Pacific Walrus* | *47* | *82* | *2* | *2* | *0* | *0* | *11* | *16* | *13* | *18* | **73** | **118** |
| *Total Seals* | *606* | *674* | *1* | *1* | *0* | *0* | *65* | *70* | *66* | *71* | **738** | **816** |

Note: N/A means not applicable.

[a] Useable sightings are those made during useable daylight periods of visual observation, as defined in *Acronyms and Abbreviations.*

More individual gray whales (22 in 7 groups) were recorded than any other cetacean species; however the number of groups recorded was greater for bowhead whale (15) and harbor porpoise (10) than for gray whale (Table 5.3). The total number of individual bowhead whales recorded (18) was only slightly less than the number of gray whales (22). The number of cetacean groups seen from the chase vessel (40 groups of 59 individuals) was nearly twice the number of groups seen from the *Patriot* (22 groups of 25 individuals; see Tables ES.1 and 5.3). Pinniped sightings from the chase vessel (829) were nearly 6 times the number recorded from the *Patriot* (142). A detailed list of sightings is provided in Appendix Table G.4.

TABLE 5.3. Number of marine mammal sightings from the *Patriot* (17 Jul.−14 Oct. 2006) and chase vessel (14 Jul.−14 Oct. 2006) during the Chukchi Sea cruise, and number that were "useable" in analyses. Numbers in parentheses are numbers of individuals.

| | ***Patriot*** Sightings (Individuals) | | ***Chase Vessel*** Sightings (Individuals) | | ***Total*** Sightings (Individuals) | |
|---|---|---|---|---|---|---|
| **Species** | **All** | **Useable[a]** | **All** | **Useable[a]** | **All** | **Useable[a]** |
| **Cetaceans** | | | | | | |
| Beluga Whale | 2(2) | 0 | 1(1) | N/A | ***3(3)*** | ***0*** |
| Harbor Porpoise | 0 | 0 | 10(13) | N/A | ***10(13)*** | ***0*** |
| Bowhead Whale | 4(4) | 3(3) | 11(14) | N/A | **15(18)** | ***3(3)*** |
| Gray Whale | 4(7) | 2(4) | 3(15) | N/A | ***7(22)*** | ***2(4)*** |
| Minke Whale | 0 | 0 | 2(2) | N/A | ***2(2)*** | ***0*** |
| Unidentified Mysticete Whale | 7(7) | 5(5) | 1(1) | N/A | ***9(10)*** | ***5(5)*** |
| Unidentified whale | 5(5) | 0 | 8(8) | N/A | ***13(13)*** | ***0*** |
| Unidentified dolphin | 0 | 0 | 4(5) | N/A | ***4(5)*** | ***0*** |
| ***Total Cetaceans*** | ***22(25)*** | ***10(12)*** | ***40(59)*** | ***N/A*** | ***63(86)*** | ***10(12)*** |
| **Pinnipeds** | | | | | | |
| Unidentified Pinniped | 6(6) | 5(5) | 2(2) | 1(1) | ***8(8)*** | ***6(6)*** |
| Pacific Walrus | 23(32) | 13(18) | 64(105) | 47(82) | ***87(137)*** | ***60(100)*** |
| Bearded Seal | 10(13) | 7(10) | 56(56) | 44(44) | ***66(69)*** | ***51(54)*** |
| Ribbon Seal | 0 | 0 | 1(1) | 0 | ***1(1)*** | ***0*** |
| Ringed Seal | 17(17) | 8(8) | 342(380) | 266(301) | ***359(397)*** | ***274(309)*** |
| Spotted Seal | 9(10) | 6(7) | 43(45) | 33(34) | ***52(55)*** | ***39(41)*** |
| Unidentified Seal | 77(80) | 45(46) | 321(356) | 263(295) | ***398(436)*** | ***308(341)*** |
| ***Total Pinnipeds*** | ***142(158)*** | ***84(94)*** | ***829(945)*** | ***654(757)*** | ***971(1103)*** | ***738(851)*** |
| *Total Seals* | *113(120)* | *66(71)* | *736(838)* | *606(674)* | *876(958)* | *672(745)* |
| ***Total Marine Mammals*** | ***164(183)*** | ***94(106)*** | ***869(1004)*** | ***654(757)*** | ***1034(1189)*** | ***748(863)*** |

Note: N/A means not applicable.
[a] Useable sightings are those made during useable daylight periods of visual observation, as defined in *Acronyms and Abbreviations.*

Most of the 1034 sightings of marine mammals (75% or 777 groups) made within the study area were “useable” (Tables 5.2, 5.3). These “useable” sightings, along with the corresponding effort data, are the basis for the ensuing analyses comparing sighting rates and behaviors of marine mammals. There were no useable sightings of Odontocetes, all useable cetacean sightings were of Mysticetes.

No deaths or injury of animals was observed during the seismic program. Some carcasses of whales, seals, and walruses were sighted, these are included in the summary of marine mammal sightings (Appendix Table G.4). Where feasible, which was the majority of cases, carcasses were approached at closer range by the chase vessel, observed in detail and photographed by the MMOs. All carcasses showed signs of advanced decomposition, indicating that they had died well before seismic operations had started.

***Sightings with Airguns On***.—Of the total 1034 sightings, 148 were made from the *Patriot* during the 1738 h of airgun operations; 884 were made during 1329 h of non-seismic periods from the *Patriot* and chase vessels; and the single remaining sighting was noted during 10 h of “post-seismic” periods from the *Patriot (*Appendix Table E.1, Table 5.2).

Power downs were requested on 44 occasions and a shut down was requested on 1 occasion when an unidentified seal was sighted in the water within the 190 dB (rms) safety radii around the operating airguns. Further details on these encounters are provided later in this chapter (see *Marine Mammals Potentially Exposed to Sounds ≥180 dB*) and in Appendix H.

***Sighting Rates***.—Sighting rates (# groups sighted per unit effort) during various types of MMO effort are presented in Table 5.1. Sighting rates for all categories of pinnipeds from the chase vessel were much greater than sighting rates from the *Patriot*. This may have resulted in part from chase vessel activities near the ice edge where marine mammal densities may have been greater than in open water areas where the *Patriot* typically operated. Marine mammal sightings from the *Patriot* may also have been reduced due to avoidance of airgun sound by marine mammals in the immediate area of the *Patriot*.

Sighting rates of cetaceans (animals/km) from the *Patriot* were greater during non-seismic operations than during seismic conditions but sample sizes are small (Table 5.1). The reverse was true for pinniped sighting rates from the *Patriot*; which were nearly 4 × greater during seismic than non-seismic periods. This trend was true for both useable and non-useable data (Table 5.1). The highest sighting rate for pinnipeds was observed during post-seismic periods (11.0 detections/1000km), but the sample size was small and the data were "non-useable".

When all data are considered (i.e., data from the chase vessel and the *Patriot*), sighting rates are greater for all marine mammal groups during non-seismic than seismic or post-seismic periods (Table 5.1). This is largely due to the high sighting rates from the chase vessel which were all considered to be unaffected by seismic activities. Pooling these data with the sighting rate data from the *Patriot* results in an overall higher sighting rate for all groups during non-seismic periods, but as noted above, these rates may not accurately represent sighting rates in open-water areas because some chase vessel activities were in areas of moderate ice cover where pinnipeds are more frequently encountered.

The presence of fog (visibility <3.5 km) was the most common reason that sightings were considered non-useable. During the surveys from the *Patriot*, the detection rate during non-useable periods was generally reduced compared to that during useable periods, consistent with what would be expected during periods of poor vs. good visibility (Table 5.1). For the chase vessel, sighting rates were higher for all groups for useable rather than non-useable data.

***Other Vessels***.—While the *Patriot* and chase vessel worked in tandem, the vessels were typically within ~6-8 km of each other and often as close as a few hundreds of meters of each other. The location and proximity of the chase vessel was extremely variable, and probably had some effect on the number of sightings and the behavior of marine mammals that were sighted. This effect, however, was not apparent to the MMOs in real time when they were observing marine mammals. Other than the *Torsvik* and *Gulf Provider*, one other chase/supply vessel associated with industry activities, the *Kilabuk*, was sighted occasionally. The seismic vessel *Gilavar* was seen by the MMOs on four occasions while it was transiting through the CPAI survey area.. There were also rare observations of other vessels (a Coast Guard ship and two barges) within the project area for short periods of time which likely had little affect on the distribution and behavior or marine mammals in the area of the *Patriot's* seismic activities.

## *Distribution of Marine Mammals*

Observations during the Chukchi Sea study indicate that ringed seals were the most abundant marine mammals in the area (Tables 5.2, 5.3). It is expected that the majority of unidentified seals were ringed seals as bearded seals would be more easily confused with Pacific walruses (because of their size) and therefore classified as unknown pinnipeds. Pacific walruses were more abundant than bearded seals. All species of pinnipeds, with the exception of the one sighting of a ribbon seal, were seen during both seismic and non-seismic periods.

The bowhead whale was the most frequently encountered cetacean species, followed by the harbor porpoise (Tables 5.2, 5.3). Although bowhead whale sightings were most frequent, gray whales were the

most abundant cetacean observed during the project. Gray, beluga, and minke whales were seen on multiple occasions. Bowhead, gray, and beluga whales were seen during both seismic and non-seismic periods. Harbor porpoises and minke whales were seen only during non-seismic periods.

Specific locations of sightings are not mapped given the sensitivity of information about the exact locations where the seismic survey was done (see Chapter 2).

## *Marine Mammal Behavior*

The data collected during visual observations also provide information about behavioral responses of marine mammals to the seismic survey. The relevant data include estimated closest observed points of approach (CPA) to the vessel, movement relative to the vessel when the airguns were and were not firing, and observed behavior of animals at the time of the initial sightings.

### *Closest Observed Point of Approach*

When useable sightings of pinnipeds in water were combined from the Patriot and chase vessel, CPA distance during non-seismic periods was significantly less than CPA during seismic periods (Wilcoxon rank sum test, n = 81 vs. 655; Z = 3661, P = 0.000). The mean CPA of seals observed from the chase vessel was also less than the mean CPA from the Patriot during both non-seismic and seismic periods (Tables 5.4, 5.5). The CPAs for other species and species groups are shown in Figure 5.1 but sample sizes were too small to permit comparisons. No odontocete whales were observed from the Patriot.

Although most sample sizes are small, the sighting-distance data from this study are consistent with those from many previous seismic studies. In those studies, marine mammals were usually observed at greater distances from the vessel and at lower sighting rates when the airguns were operating than when the airguns were silent (e.g., Smultea et al. 2004; Haley and Koski 2004; MacLean and Koski 2005; Holst et al. 2005a,b).

### *Categories of Behavior*

Marine mammal behavior is difficult to observe, especially from a seismic vessel, because individuals and/or groups are often at the surface only briefly, and there may be avoidance behavior. This causes difficulties in resighting those animals, and in determining whether two sightings some minutes apart are repeat sightings of the same individual(s). Only limited behavioral data were collected during this project because marine mammals were often seen at a distance from the vessel, and they were typically not tracked for long distances or durations while the vessel was underway. The two variables that were examined quantitatively to assess potential seismic effects on behavior were the categories of movement and behavior when the animal(s) were first observed (see Appendix Table E.1 for variables and definitions). The CPA distance recorded for each sighting was also an indicator of behavior (see above and Appendix Table G.4 for details on sightings). Results regarding movement and behavior are presented in Tables 5.6 and 5.7. (In those tables, cetacean data include only useable sightings from the *Patriot*; however, seal and walrus data include useable sightings from both the *Patriot* and the chase vessel.)

***Movement***.—Movement was observed and recorded for ten sightings of cetaceans (Table 5.6). (Of the total ten cetacean sightings, there were six sightings for which movement was either unknown or not recorded.) Of the three sightings during non-seismic periods for which movement was recorded, all were of cetaceans swimming parallel to the vessel (Table 5.6). The one cetacean sighting made during seismic activity, for which the movement was known/recorded, was also of an animal swimming parallel to the vessel.

TABLE 5.4. Closest observed points of approach (CPA) of useable marine mammal sightings from the Patriot to the airguns during non-seismic and seismic periods during the Chukchi Sea survey (17 Jul.–14 Oct. 2006).

| | | Non-seismic | | | | Seismic | | | |
|---|---|---|---|---|---|---|---|---|---|
| Taxonomic Group[ab] | # Sightings | Mean CPA (m) | s.d. | *n* | Range (m) | Mean CPA (m) | s.d. | *n* | Range (m) |
| **Seals** | 66 | 335 | 0 | 1 | 335 - 335 | 486 | 230 | 65 | 30 - 1534 |

[a] Includes only useable sightings as defined in *Acronyms and Abbreviations.*
[b] Only taxonomic groups with sample size greater than 13 sightings total are presented.

TABLE 5.5. Closest observed points of approach (CPA) of useable seal sightings to observers on board the chase vessel during non-seimic periods during the Chukchi Sea survey from (14 Jul.–14 Oct. 2006).

| | | Non-seismic | | |
|---|---|---|---|---|
| Taxonomic Group[ab] | # Sightings | Mean CPA (m) | s.d. | Range (m) |
| **Seals** | 606 | 120 | 145 | 2 - 1011 |

[a] Includes only useable sightings as defined in *Acronyms and Abbreviations.*
[b] Only taxonomic groups with a sample size greater than 45 sightings total are presented.

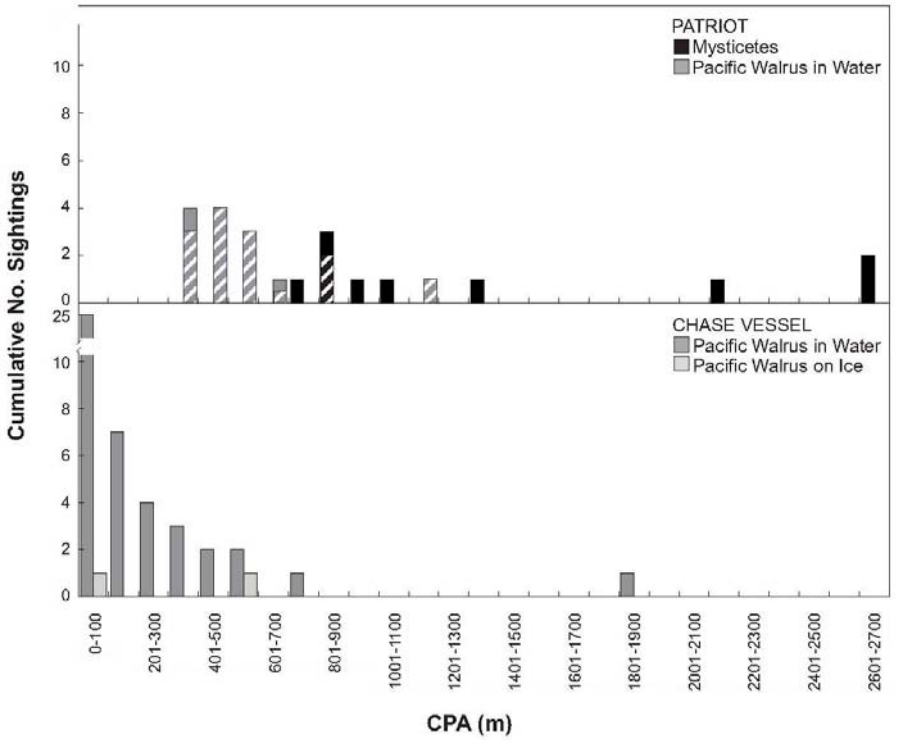


FIGURE 5.1. Closest observed point of approach (CPA) of useable mysticete and Pacific walrus sightings from the *Patriot* (top panel) and the chase vessel (bottom panel). Solid color represents animals observed during non-seismic periods. Hatched areas represent animals observed during seismic periods.

TABLE 5.6. Numbers of useable sightings of marine mammals by movement category during seismic and non-seismic periods from the *Patriot* (17 Jul.–14 Oct. 2006) and the chase vessel (14 Jul.–14 Oct. 2006) within the Chukchi Sea. Pinnipeds on ice are included in this table under the "hauled out" category. See Appendix E for definitions of movement categories

| | Movement Relative to Vessel[a] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Taxonomic Group[b] | Mill | Flee | Swim Perpen-dicular | Swim Away | Swim Parallel | Swim Toward | Hauled Out | No Movement | Total of Known/Recorded Movement | Unknown/ Not Recorded | *Total* |
| **Cetaceans** | | | | | | | | | | | |
| Non-seismic | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 | 5 | ***8*** |
| Seismic | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | ***2*** |
| ***Total*** | ***0*** | ***0*** | ***0*** | ***0*** | ***4*** | ***0*** | ***0*** | ***0*** | ***4*** | ***6*** | ***10*** |
| **Seals** | | | | | | | | | | | |
| Non-seismic | 21 | 2 | 25 | 139 | 94 | 60 | 0 | 249 | 590 | 17 | ***607*** |
| Seismic | 3 | 0 | 4 | 42 | 4 | 3 | 0 | 5 | 61 | 4 | ***65*** |
| ***Total*** | ***24*** | ***2*** | ***29*** | ***181*** | ***98*** | ***63*** | ***0*** | ***254*** | ***651*** | ***21*** | ***672*** |
| **Unidentified Pinnipeds** | | | | | | | | | | | |
| Non-seismic | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | ***1*** |
| Seismic | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 2 | ***5*** |
| ***Total*** | ***1*** | ***0*** | ***0*** | ***0*** | ***0*** | ***0*** | ***0*** | ***2*** | ***3*** | ***3*** | ***6*** |
| **Pacific Walrus** | | | | | | | | | | | |
| Non-seismic | 3 | 0 | 3 | 17 | 10 | 1 | 2 | 9 | 45 | 4 | ***49*** |
| Seismic | 1 | 0 | 0 | 3 | 3 | 2 | 0 | 1 | 10 | 1 | ***11*** |
| ***Total*** | ***4*** | ***0*** | ***3*** | ***20*** | ***13*** | ***3*** | ***2*** | ***10*** | 55 | ***5*** | ***60*** |
| **Unknown Species** | | | | | | | | | | | |
| Seismic | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ***1*** | ***1*** |

[a] Includes only useable sightings as defined in *Acronyms and Abbreviations*.
[b] Cetacean sightings include only those from the *Patriot*; seal, unidentified pinnipeds, Pacific walrus, and unknown species sightings include those from the *Patriot* and the chase vessel. See text for explanation.

A total of 651 seal sightings had movement records. Of those seal sightings, 590 sightings were during non-seismic periods and 61 sightings were made during seismic periods. During non-seismic periods, those seals for which movement was recorded were most often seen not moving relative to the vessel (42%, Table 5.6). Swimming away (24%), swimming parallel (16%), and swimming toward (10%) were the next most frequently-observed movements in relation to the vessel for seals, during non-seismic periods. During seismic periods, those seals for which movement was recorded were most often seen swimming away from the vessel (69%, Table 5.6). Not moving (8%), swimming perpendicular or parallel (7%), and swimming toward and milling (5%) were the other movements recorded for seals during seismic operations.

Two of the 55 sightings of walruses for which movement was recorded (4%) were of animals hauled out on the ice (Table 5.6). Seventeen of the 45 sightings (29%) of walruses in the water during non-seismic periods were of animals swimming away, ten (22%) were of animals swimming parallel, and nine (20%) were of animals not moving relative to the ship. During seismic activity, walrus movement was most often swimming away from or swimming parallel to the vessel (30% for each, Table 5.6).

***First Observed Behavior***.—The most common "first observed behavior" of cetaceans was blowing (7 of 10 sightings, or 70%; Table 5.7). For observations of seals with known behavior, looking and swimming/travelling were the most common "first observed behaviors" during non-seismic periods, accounting for 55% and 28% of the 600 non-seismic sightings respectively. However, swimming/travelling was observed first most often during seismic periods (32 of 61 sightings, or 52%). Thirty percent (18 of 61) of sightings of seals during seismic periods were of animals looking. Behavior was recorded for 45 sightings of Pacific walrus in the water during non-seismic periods, and 10 sightings during seismic periods. The most common first-observed behavior of walruses in water during non-seismic periods was looking followed by swimming/traveling. These two behaviors comprised 76% of the behaviors recorded for walruses in water during non-seismic periods. Walrus behavior during seismic periods followed a similar pattern. Few walruses were observed on ice.

TABLE 5.7. Comparison of first observed behaviors of useable marine mammal sightings during non-seismic and seismic periods from the *Patriot* (17 Jul.–14 Oct. 2006) and the chase vessel (14 Jul.–14 Oct. 2006) within the Chukchi Sea. See Appendix E for definitions of behavior categories.

| | First-observed Behavior[a] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxonomic Group[b]** | **Blow** | **Fluke** | **Dive / Forward Dive** | **Swim / Travel** | **Porpoise/ Surface Active Travel** | **Log / Raft** | **Rest** | **Spyhop / Look** | **Sink** | **Thrash** | **Flipper Slap** | **Feed** | **Mill** | **Surface Active** | **Total of Known/Recorded Behavior** | **Behavior Unknown/Not Recorded** | ***Total*** |
| **Cetaceans** | | | | | | | | | | | | | | | | | |
| Non-seismic | 5 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | ***8*** |
| Seismic | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | ***2*** |
| ***Total*** | ***7*** | ***0*** | ***0*** | ***3*** | ***0*** | ***0*** | ***0*** | ***0*** | ***0*** | ***0*** | ***0*** | ***0*** | ***0*** | ***0*** | ***10*** | ***0*** | ***10*** |
| **Seals** | | | | | | | | | | | | | | | | | |
| Non-seismic | 0 | 2 | 37 | 169 | 1 | 16 | 4 | 328 | 15 | 23 | 2 | 1 | 0 | 2 | 600 | 7 | ***607*** |
| Seismic | 0 | 0 | 3 | 32 | 4 | 0 | 0 | 18 | 0 | 4 | 0 | 0 | 0 | 0 | 61 | 4 | ***65*** |
| ***Total*** | ***0*** | ***2*** | ***40*** | ***201*** | ***5*** | ***16*** | ***4*** | ***346*** | ***15*** | ***27*** | ***2*** | ***1*** | ***0*** | ***2*** | ***661*** | ***11*** | ***672*** |
| **Unidentified Pinnipeds** | | | | | | | | | | | | | | | | | |
| Non-seismic | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | ***1*** |
| Seismic | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 5 | 0 | ***5*** |
| ***Total*** | ***0*** | ***0*** | ***0*** | ***4*** | ***0*** | ***0*** | ***0*** | ***1*** | ***0*** | ***1*** | ***0*** | ***0*** | ***0*** | ***0*** | ***6*** | 0 | ***6*** |
| **Pacific Walrus in Water** | | | | | | | | | | | | | | | | | |
| Non-seismic | 0 | 0 | 4 | 13 | 2 | 0 | 0 | 21 | 3 | 0 | 0 | 0 | 1 | 1 | 45 | 2 | ***47*** |
| Seismic | 0 | 0 | 0 | 5 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 1 | ***11*** |
| ***Total*** | ***0*** | ***0*** | ***4*** | ***18*** | ***2*** | ***1*** | ***0*** | ***25*** | ***3*** | ***0*** | ***0*** | ***0*** | ***1*** | ***1*** | ***55*** | ***3*** | ***58*** |
| **Pacific Walrus on Ice** | | | | | | | | | | | | | | | | | |
| Non-seismic | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | ***2*** |
| Seismic | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ***0*** |
| ***Total*** | ***0*** | ***0*** | ***0*** | ***0*** | ***0*** | ***0*** | ***2*** | ***0*** | ***0*** | ***0*** | ***0*** | ***0*** | ***0*** | ***0*** | ***2*** | ***0*** | ***2*** |
| **Unknown Species** | | | | | | | | | | | | | | | | | |
| Seismic | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | ***1*** |

[a] Includes only useable sightings as defined in *Acronyms and Abbreviations*.

[b] Cetacean sightings include only those from the *Patriot*; seal, unidentfied pinniped, Pacific Walrus, and unknown species sightings include those from the *Patriot* and the chase vessel. See text for explanation.

## *Mitigation Measures Implemented*

A total of 44 power downs and 1 shut down of the airguns was requested due to 45 sightings of 53 marine mammals approaching or within the safety radii applied during the Chukchi Sea cruise (Table 5.8; for a full account of each power down and shut down, see Appendix H). A power down was required when cetaceans approached within the "180 dB rms" safety radius of 1100 m from the *Patriot*'s airgun array. A full shut down was required if cetaceans approached within 154 m of the array (following a power down). The applied "190 dB rms" safety radii for pinnipeds were 500 m for a power down and 145 m for a shut down (Table 4.1). The safety radii were somewhat smaller than the measured 180 and 190 dB rms sound level distances, especially with respect to the 180 dB rms distances which were not uniform around the vessel (see Tables 4.1, 4.4). When assessing the likelihood of exposures to ≥180 dB rms (Table 5.8), the endfire aspect 180 dB rms measurement of 1112 m was used if the animal was ahead of the vessel, whereas if the animal was beside the vessel, the broadside aspect 180 dB rms distance of 1628 m was used. For animals potentially exposed to ≥190 dB rms (Table 5.8), the broadside aspect distance of 517 m was used throughout (since it was nearly identical to the endfire distance of 514 m). Sound levels are also not uniform with depth (Greene and Richardson 1988; Tolstoy et al. 2004a,b), so animals would need to dive well below the surface to encounter sound levels ≥180 dB rms or ≥190 dB rms near the measured sound level distances.

Only two mitigation measures were implemented for cetacean sightings, while the majority of power downs and the only shut down were in response to pinniped sightings. Most sightings involved individuals, but there were seven mitigation measures implemented for groups of two to three animals, the majority involving Pacific walruses (five sightings). Broken down by species, the two sightings of cetaceans requiring mitigation measures involved gray whales (1 sighting, 2 individuals) and a bowhead whale (1 sighting, 1 individual). The 43 sightings of pinnipeds involved unidentified seals (23 sightings, 24 individuals), Pacific walruses (10 sightings, 16 individuals), ringed seals (7 sightings, 7 individuals), bearded seals (2 sightings, 2 individuals), and an unidentified pinniped (1 sighting, 1 individual).

During the two cetacean sightings, the full 3390 $in^3$ array was firing. The two gray whales (sighting 82; Table 5.8) approached the full array underwater, coming within 360 m of the array (well within the 180 dB rms distance of 1628 m beside the vessel) before a power down was implemented, and were very likely exposed to ≥180 dB rms. They were also within the 190 dB rms distance of 517 m, so were likely also exposed to ≥190 dB rms. The individual bowhead whale (sighting 13; Table 5.8) surfaced within 834 m of the full array before a power down occurred (within the 180 dB rms distance of 1112 m ahead of the vessel), so was likely exposed to sounds ≥180 dB rms, but not to sounds ≥190 dB rms. The cetaceans likely exposed to ≥180 dB rms therefore include two gray whales and one bowhead whale, and those likely exposed to ≥190 dB rms include the two gray whales.

There were 32 cases involving 33 seals requiring mitigation measures, including the only shut down of the single mitigation airgun. An unidentified seal was sighted ~30 m from the mitigation airgun and a shut down was requested. This seal was very likely exposed to ≥190 dB rms (sighting 30; Table 5.8). The remaining 31 cases involving 32 seals resulted in power downs of the full 3390 $in^3$ array. Sightings 124 and 145 (Table 5.8) involved two individual unidentified seals that were sighted ahead of the vessel and were still outside the 517 m 190 dB rms distance when the power down occurred, so these seals were unlikely to have been exposed to ≥190 dB rms. In all of the remaining 30 cases involving 31 seals, animals were likely (including the "Likely" and "Very likely" categories; Table 5.8) exposed to ≥190 dB rms, since they either surfaced or dove within the 190 dB rms distance before a mitigation measure was implemented, or were initially sighted within the 190 dB rms distance and assumed to be exposed to ≥190 dB rms before being detected. The 31 seals likely exposed to ≥190 dB rms include 22 unidentified seals, 7 ringed seals, and 2 bearded seals.

TABLE 5.8. List of power downs (PZ) and shut downs (SZ) of the airguns implemented for pinnipeds sighted in or near the *Patriot's* safety radii (500 m for power downs, 145 m for shut downs), as well as those mitigation measures implemented for cetaceans (1100 m safety radius for power downs, 154 m safety radius for shut downs), during the Chukchi Sea seismic survey (17 Jul.−14 Oct. 2006). See Appendix Table G.4 for more details on these sightings. Also see Appendix H for an account of each power down and shut down.

| Sighting ID | Species | Group Size | Day in 2006 | Initial Sighting Distance (m) from observer | Initial Movement[a] | Underwater before mitigation?[b] | Total airgun Vol. ($in^3$) prior to SZ or PZ | Measured 180 dB[c] sound level distance (m) | Measured 190 dB[d] sound level distance (m) | CPA (m) to airguns before mitigation | Mitigation measure taken (SZ, PZ) | Exposed to ≥180 dB re 1 µPa (rms)?[e] | Exposed to ≥190 dB re 1 µPa (rms)?[e] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | Bowhead Whal | 1 | 24-Jul | 756 | UN | Yes[f] | 3390 | 1112 | 517 | 824 | PZ | Likely | Very unlikely |
| 30 | Unidentified Se | 1 | 26-Jul | 272 | SA | Yes | 105 | – | 62 | 30 | SZ | – | Very likely |
| 36 | Ringed Seal | 1 | 26-Jul | 6 | SA | Yes[f] | 3390 | – | 517 | 303 | PZ | – | Very likely |
| 39 | Ringed Seal | 1 | 29-Jul | 150 | SA | Yes | 3390 | – | 517 | 397 | PZ | – | Likely |
| 41 | Unidentified Se | 1 | 29-Jul | 150 | MI | Yes | 3390 | – | 517 | 397 | PZ | – | Likely |
| 42 | Ringed Seal | 1 | 29-Jul | 40 | SA | Yes | ≤ 3390 | – | ≤ 517 | 322 | PZ | – | Likely |
| 43 | Bearded Seal | 1 | 1-Aug | 84 | SA | Yes[f] | 3390 | – | 517 | 350 | PZ | – | Very likely |
| 44 | Unidentified Se | 1 | 3-Aug | 25 | UN | Yes | 3390 | – | 517 | 313 | PZ | – | Likely |
| 45 | Unidentified Se | 1 | 3-Aug | 50 | NO | Yes | ≤ 3390 | – | ≤ 517 | 350 | PZ | – | Likely |
| 46 | Ringed Seal | 1 | 3-Aug | 50 | SP | Yes | ≤ 3390 | – | ≤ 517 | 328 | PZ | – | Very likely |
| 47 | Unidentified Se | 1 | 3-Aug | 100 | SA | Yes | 3390 | – | 517 | 344 | PZ | – | Likely |
| 48 | Unidentified Se | 1 | 3-Aug | 100 | SA | No | 3390 | – | 517 | 360 | PZ | – | Likely |
| 50 | Pacific Walrus | 1 | 3-Aug | 200 | MI | No | 3390 | – | 517 | 484 | PZ | – | Likely |
| 51 | Unidentified Pin | 1 | 4-Aug | 40 | UN | Yes | 3390 | – | 517 | 322 | PZ | – | Very likely |
| 52 | Pacific Walrus | 2 | 5-Aug | 14 | SA | No | 3390 | – | 517 | 300 | PZ | – | Likely |
| 53 | Unidentified Se | 1 | 6-Aug | 60 | UN | No | 3390 | – | 517 | 334 | PZ | – | Likely |
| 62 | Ringed Seal | 1 | 16-Aug | 200 | MI | Yes | 3390 | – | 517 | 335 | PZ | – | Very likely |
| 68 | Unidentified Se | 1 | 17-Aug | 20 | SA | Yes | 3390 | – | 517 | 310 | PZ | – | Very likely |
| 72 | Pacific Walrus | 3 | 17-Aug | 200 | SA | Yes | 3390 | – | 517 | 436 | PZ | – | Likely |
| 82 | Gray Whale | 2 | 29-Aug | 2500 | PE | Yes[f] | 3390 | 1628 | 517 | 360 | PZ | Very likely | Likely |
| 85 | Pacific Walrus | 1 | 30-Aug | 207 | SA | No | 3390 | – | 517 | 442 | PZ | – | Likely |
| 87 | Pacific Walrus | 2 | 30-Aug | 150 | SA | No | 3390 | – | 517 | 436 | PZ | – | Likely |
| 89 | Bearded Seal | 1 | 30-Aug | 192 | NO | No | 3390 | – | 517 | 476 | PZ | – | Likely |
| 97 | Unidentified Se | 1 | 31-Aug | 178 | NO | No | ≤ 3390 | – | ≤ 517 | 418 | PZ | – | Likely |
| 99 | Unidentified Se | 1 | 31-Aug | 225 | UN | No | ≤ 3390 | – | ≤ 517 | 456 | PZ | – | Likely |
| 105 | Unidentified Se | 1 | 31-Aug | 150 | SA | Yes | 3390 | – | 517 | 450 | PZ | – | Likely |
| 106 | Unidentified Se | 2 | 31-Aug | 60 | SA | No | ≤ 3390 | – | ≤ 517 | 353 | PZ | – | Likely |
| 107 | Pacific Walrus | 2 | 1-Sep | 178 | SP | No | 3390 | – | 517 | 418 | PZ | – | Likely |
| 108 | Unidentified Se | 1 | 2-Sep | 40 | SA | Yes | 3390 | – | 517 | 340 | PZ | – | Likely |
| 109 | Ringed Seal | 1 | 2-Sep | 50 | MI | No | 3390 | – | 517 | 278 | PZ | – | Likely |
| 110 | Unidentified Se | 1 | 4-Sep | 50 | PE | No | ≤ 3390 | – | ≤ 517 | 350 | PZ | – | Likely |
| 111 | Ringed Seal | 1 | 10-Sep | 25 | PE | No | 3390 | – | 517 | 322 | PZ | – | Likely |
| 115 | Unidentified Se | 1 | 15-Sep | 150 | SA | No | 3390 | – | 517 | 397 | PZ | – | Likely |
| 119 | Pacific Walrus | 2 | 22-Sep | 200 | ST | No | 3390 | – | 517 | 436 | PZ | – | Likely |
| 120 | Unidentified Se | 1 | 23-Sep | 40 | SA | Yes | 3390 | – | 517 | 322 | PZ | – | Very likely |
| 124 | Unidentified Se | 1 | 24-Sep | 306 | ST | No | 3390 | – | 517 | 585 | PZ | – | Unlikely |
| 127 | Unidentified Se | 1 | 24-Sep | 50 | SA | Yes | 3390 | – | 517 | 350 | PZ | – | Likely |
| 135 | Unidentified Se | 1 | 25-Sep | 584 | SA | Yes[f] | 3390 | – | 517 | 400 | PZ | – | Likely |
| 136 | Pacific Walrus | 1 | 25-Sep | 273 | ST | Yes | ≤ 3390 | – | ≤ 517 | 496 | PZ | – | Likely |
| 137 | Pacific Walrus | 1 | 25-Sep | 347 | NO | No | 3390 | – | 517 | 484 | PZ | – | Unlikely |
| 139 | Pacific Walrus | 1 | 28-Sep | 80 | SP | Yes | 3390 | – | 517 | 371 | PZ | – | Likely |
| 140 | Unidentified Se | 1 | 29-Sep | 30 | SA | Yes | 3390 | – | 517 | 330 | PZ | – | Very likely |
| 141 | Unidentified Se | 1 | 29-Sep | 20 | SA | Yes | 3390 | – | 517 | 320 | PZ | – | Likely |
| 142 | Unidentified Se | 1 | 29-Sep | 15 | SA | Yes | 3390 | – | 517 | 315 | PZ | – | Likely |
| 145 | Unidentified Se | 1 | 29-Sep | 347 | SA | Yes | 3390 | – | 517 | 647 | PZ | – | Unlikely |

[a] Initial movement of group relative to vessel: PE=swimming perpendicular or across bow, ST=swimming toward, SA=swimming away, SP=swimming parallel, MI=milling, NO=none, UN=unknown.
[b] Was the animal observed surfacing or diving before the mitigation measure was implemented?
[c] Sound level of concern for cetaceans; full array 180 dB rms distance measured from broadside aspect was 1628 m, and measured from endfire aspect was 1112 m.
[d] Sound level of concern for pinnipeds (and cetaceans); full array 190 dB rms distance measured from broadside aspect was 517 m (very similar to the endfire distance of 514 m); single gun 190 dB rms distance was 62 m.
[e] Categories for likelihood of exposure range from least likely to most likely: Very unlikely, Unlikely, Likely, Very likely.
[f] In this case, the animal(s) were observed surfacing within the 180 or 190 dB rms distance before a power down occurred; in all other "Yes" cases, the animal(s) were observed diving before the mitigation measure was implemented.

Finally, power downs were implemented for one sighting of an unidentified pinniped, as well as 10 sightings of 16 Pacific walruses, including two walrus calves. The unidentified pinniped was possibly a walrus (sighting 52; Appendix H), which approached the fully operating airgun array within 322 m and dove before a power down occurred. It was very likely exposed to ≥190 dB rms. There was one sighting of a Pacific walrus (sighting 137; Table 5.8) where the animal was initially sighted outside the 190 dB rms distance of 517 m and remained at the surface until after the power down occurred. This animal was

unlikely to have been exposed to ≥190 dB rms. For the remaining nine cases involving 15 walruses (including two calves), the animals either dove within the 190 dB rms distance before a power down occurred, or were initially sighted within the 190 dB rms distance and were likely exposed to ≥190 dB rms before being detected. The unidentified pinniped and 15 of the walruses (including two calves) were therefore likely (including the "Likely" and "Very likely" categories; Table 5.8) exposed to ≥190 dB rms.

There were 14 cases involving 15 pinnipeds where animals may have been ensonified at ≥190 dB rms without mitigation measures being implemented. In two of these cases involving two single seals (sighting 102 and 112; Table G.4), a power down was appropriate, but the sightings coincided with the end of a seismic line, therefore the airguns were already in the process of powering down to the single mitigation airgun. There were three cases involving two single seals and a single Pacific walrus (sightings 69, 77, and 86; Table G.4), where animals were sighted within the 500 m safety radius, but the MMO did not request a power down. In eight cases involving five single seals and three single Pacific walruses, MMO's estimated sighting distances relative to themselves, and then also separately estimated that the animals were still outside the 500 m safety radius relative to the airguns (sightings 35, 67, 100, 103, 122, 70, 153, and 121; Table G.4). However, once the original distance estimate relative to the MMO was converted to a distance relative to the airguns in analyses, the animals were found to have been within the 500 m safety radius. In the remaining case involving two seals, the animals were sighted 507 m ahead of the airguns, just outside of the 500 m safety radius, but inside the 190 dB rms distance of 517 m, so they may have been exposed to sounds ≥190 dB rms. Therefore a total of 11 seals and four Pacific walruses were potentially ensonified at ≥190 dB rms with no mitigation measure being implemented.

There was a single case of an unknown animal (possibly a minke whale; sighting 63, Table G.4) which received ≥180 dB rms, with no mitigation measure implemented. This animal was seen once at a calculated distance of 1251 m to the airguns, off the starboard side. The MMO did not request a power down since the 180 dB safety radius was 1100 m, but the animal likely received ≥180 dB rms since the broadside 180 dB rms distance is 1628 m (Table 4.1).

## *Estimated Number of Marine Mammals Present and Potentially Affected*

It is difficult to obtain meaningful estimates of "take by harassment" for several reasons: ***(1)*** The relationship between numbers of marine mammals that are observed and the number actually present is uncertain. ***(2)*** The most appropriate criteria for "take by harassment" are uncertain and presumably variable among species and situations. ***(3)*** The distance to which a received sound level exceeds a specific criterion such as 190 dB, 180 dB, 170 dB, or 160 dB re 1 $\mu Pa_{rms}$ is variable. It depends on water depth, source depth, water-mass and bottom conditions, and—for directional sources—aspect (Chapter 3; see also Greene 1997; Greene et. al. 1998; Burgess and Greene 1999; Caldwell and Dragoset 2000; Tolstoy et al. 2004a,b). ***(4)*** The sounds received by marine mammals vary depending on their depth in the water, and will be considerably reduced for animals at or near the surface (Greene and Richardson 1988; Tolstoy et al. 2004a,b) and further reduced for animals that are on the ice.

### *Disturbance and Safety Criteria*

Table 4.1 shows the preliminary distances at which various sound levels were estimated to be received from the *Patriot's* 3390 $in^3$ 4-string airgun array. The predicted 160 and 170-dB radii are assumed behavioral disturbance criteria. The prelimimary 180 and 190 dB rms endfire distances were used as the safety radii for determining when mitigation measures were required. During this and many other recent projects, NMFS has required that mitigation measures be applied to avoid or minimize the exposure of cetaceans and pinnipeds to impulse sounds with received levels ≥180 dB and ≥190 dB,

respectively. NMFS commonly assumes that cetaceans and seals exposed to pulsed sounds with received levels ≥160 dB (rms) might be disturbed, although there is little evidence that most pinnipeds or delphinids exposed to airgun sounds with levels just above 160 dB are disturbed. The safety and disturbance radii summarized in Table 4.1 were used after the field season to estimate numbers of marine mammals exposed to various received sound levels.

This section applies two methods to estimate the number of pinnipeds and cetaceans exposed to seismic sound levels strong enough that they might have caused disturbance or other effects. The procedures include ***(A)*** minimum estimates based on direct observations, and ***(B)*** estimates based on pinniped and cetacean densities obtained during this study. The actual number of individuals exposed to, and potentially affected by, strong seismic survey sounds likely was between the minimum and maximum estimates provided below.

### *Estimates from Direct Observations*

The number of marine mammals observed close to the *Patriot* during the Chukchi Sea survey provides a minimum estimate of the number potentially affected by seismic sounds. This is likely an underestimate of the actual number potentially affected. Some animals probably moved away before coming within visual range, and not all of those that remained would have been seen by observers.

***Pinnipeds Potentially Exposed to Sounds ≥160 dB re 1 μPa$_{rms}$.***—During this project, there were 43 sightings involving 50 pinnipeds that resulted in the implementation of mitigation measures (Table 5.8). In 40 of these cases, animals were likely exposed to ≥190 dB (rms) when they dove or surfaced within the 190 dB distance. The 47 pinnipeds that were likely exposed to ≥190 dB, for which mitigation measures were implemented, include 22 unidentified seals, two bearded seals, seven ringed seals, one unidentified pinniped (possibly a Pacific walrus) and 15 Pacific walruses (including two calves). Based on direct observation and the measured dB (rms) distances (Table 4.1), an additional eight unidentified seals, two ringed seals, one spotted seal, and four Pacific walruses may have been exposed to sounds ≥190 dB without any mitigation measures being implemented. Therefore, a total of 42 seals, one unidentified pinniped, and 19 Pacific walruses were exposed to ≥190 dB. However, the number of pinnipeds "taken" at ≥160 dB (rms) includes a total of 116 seals (76 unidentified seals, 13 bearded seals, 17 ringed seals, and 10 spotted seals), six unidentified pinnipeds, and 30 Pacific walruses, for a total of 152 pinnipeds. If pinnipeds were assumed to only be harassed at noise levels ≥170 dB (rms) though, the number of animals affected would be 102 seals (67 unidentified seals, 11 bearded seals, 16 ringed seals, and eight spotted seals), five unidentified pinnipeds, and 28 Pacific walruses for a total of 135 pinnipeds.

***Cetaceans Potentially Exposed to Sounds ≥160 dB re 1 μPa$_{rms}$.***—There were two sightings involving three cetaceans that resulted in the implementation of mitigation measures (sightings 13 and 82, Table 5.8). The bowhead whale and the two gray whales were likely exposed to sounds ≥180 dB rms when they surfaced within the 180 dB distance. However, the two gray whales were also likely exposed to sounds ≥190 dB. Based on direct observation and the measured dB (rms) distances (Table 4.1), another unknown marine mammal (possibly a minke whale; sighting 63, Appendix Table G.4) was exposed to sounds ≥180 dB, with no mitigation measure implemented. The number of cetaceans "taken" overall at ≥160 dB includes two gray whales, two bowhead whales, one unidentified whale, and one unknown animal (possibly a minke whale), for a total of six cetaceans.

### *Estimates Extrapolated from Density*

The numbers of marine mammals directly sighted during the Chukchi Sea study no doubt underestimated the actual numbers present because some animals present near the trackline were likely not seen

by the MMOs. During daylight, animals are missed if they are below the surface when the ship is nearby. Some other mammals, even if they surface near the vessel, are missed because of limited visibility, intervening ice, glare, or other factors limiting sightability. High sea state (Bf) was a significant factor during limited periods of this cruise. Also, sound levels were estimated to be ≥160 dB re 1 $\mu Pa_{rms}$ out to 12.5 km. This distance was well beyond that at which MMOs can detect even the more conspicuous animals under favorable sighting conditions during daylight. Furthermore, marine mammals could not be seen effectively during periods of darkness, which occurred for increasing numbers of hours per day after 14 August, and nighttime observations were generally not required or attempted except prior to and during nighttime ramp-ups.

Some animals may have avoided the area near the seismic vessel while the airguns were firing (see Richardson et al. 1995, 1999; Stone 2003; Gordon et al. 2004; Smultea et al. 2004). Within the assumed 160–170 dB radii around the source (i.e., ~6−12.5 km), and perhaps farther away in the case of the more sensitive species and individuals, the distribution and behavior of pinnipeds and cetaceans may have been altered as a result of the seismic survey. This could occur as a result of reactions to the airguns, or as a result of reactions to the *Patriot* or the chase vessel. The extent to which the distribution and behavior of pinnipeds might be affected by the airguns is uncertain, given the variability of previous study results (Thompson et al. 1998; Harris et al. 2001; Moulton and Lawson 2002; Miller et al. 2005). However, it is safe to assume that some pinnipeds that were on the ice as the two ships approached would have gone into the water in response to the chase vessel before they were in view of observers on the *Patriot*. Likewise, it is safe to assume that some cetaceans when approached by the seismic survey would have moved away before they were in view.

The methodology used to estimate the areas exposed to received levels ≥160 dB, ≥170 dB, ≥180 dB and ≥190 dB (rms) was described briefly in Chapter 4 *Monitoring and Mitigation Methods* and in more detail in Appendix E. Densities were based on data collected from the three vessels (*Patriot*, *Torsvik*, and *Gulf Provider*) during CPAI's seismic operations in the Chukchi Sea. The density data are summarized in Appendix Table I.1.

The aforementioned densities were used to estimate both the number of total *exposures* of marine mammals to 160, 170, 180, and 190 dB, and the number of exposures of different *individual* marine mammals to these sound levels. These numbers provide estimates of the number of animals potentially affected by seismic operations, as described in Chapter 4 and Appendix E.

The estimates provided here are based on the actual amount of seismic surveying during this project. In contrast, the estimates provided in the IHA applications for this project (CPAI 2006a,b) were based on the then-anticipated amount of survey, with an allowance for the possibility that some lines would be surveyed more than once. The estimates in the IHA applications assumed that there would be less seismic surveying than actually occurred. However, the present estimates are similar to those in the IHA application because the density estimates in the application are somewhat higher densities than were actually observed. In addition, the following estimates assume that all mammals present were well below the surface where they would be exposed to the sound levels predicted in Table 4.1 at a given distance. In fact, some pinnipeds and cetaceans in the water might remain close to the surface, where sound levels would be reduced by pressure-release effects (Greene and Richardson 1988), and some pinnipeds and cetaceans may have moved away from the path of the *Patriot* before it arrived, either because the chase vessel frequently traveled in front of the *Patriot*, or because of an avoidance response to the approaching *Patriot* and/or its airguns. Thus, the following estimates, though lower than those in the IHA Application, are nonetheless likely to overstate actual numbers exposed to various received sound levels.

Estimates of the densities of pinnipeds and cetaceans are given in Appendix Table I.1, including approximate corrections for sightability biases. These corrected densities were used to estimate the number of marine mammals that would have been exposed to various received levels of airgun sound if they did not avoid the source vessel, and thus potentially would be affected by seismic operations (Tables 5.9 and 5.10).

***Pinnipeds***.—Table 5.9 summarizes the estimated numbers of pinnipeds that might have been exposed to received sounds with various levels relative to the number of "takes" requested in CPAI's IHA application for the Chukchi Sea. These estimates are based on the ensonified area figures from Appendix Table E.2 and the density data from Appendix Table I.1. The latter Appendix table gives the density estimates derived from vessel-based surveys during both non-seismic and seismic periods. Note that the estimated numbers in Table 5.9A, based on density data from non-seismic periods, represent the pinnipeds that would have been exposed had the animals not shown localized avoidance of the airguns or the ship itself, and assume that all pinnipeds present were in the water. Some of the animals calculated (based on density) to be within the ≥190 dB zone would in fact move away before being exposed to sounds that strong. Also, some of those calculated to be in the ≥160- or ≥170 dB zones would be on the ice and not exposed to the underwater sounds.

TABLE 5.9. Estimated numbers of individuals exposed and mean numbers of exposures for each individual pinniped during CPAI seismic operations in the Chukchi Sea during 2006. Estimated numbers that might have been exposed to received levels of sounds at various levels are shown for (1) seals and (2) Pacific walrus. Requested takes for the Chukchi Sea are also shown. Estimates are based on "corrected" densities of pinnipeds calculated from sighting effort during the 2006 surveys (see text in Chapter 5 for species-specific estimates).

| | **Based on Non-seismic density[a]** | | **Based on Seismic density[a]** | | |
|---|---|---|---|---|---|
| **Exposure level in dB re 1µPa (rms)** | **Individuals** | **Exposures per Individual** | **Individuals** | **Exposures per Individual** | ***Requested Take*** |
| **Seals** | | | | | |
| **≥160** | 12,403 | 11.6 | 1,718 | 11.6 | 12,701 |
| **≥170** | 6,824 | 8.3 | 945 | 8.3 | |
| **≥180** | 3,653 | 5.1 | 506 | 5.1 | |
| **≥190** | 2,095 | 2.7 | 290 | 2.7 | |
| **Pacific Walrus** | | | | | |
| **≥160** | 351 | 11.6 | 150 | 11.6 | 3652 |
| **≥170** | 193 | 8.3 | 82 | 8.3 | |
| **≥180** | 103 | 5.1 | 44 | 5.1 | |
| **≥190** | 59 | 2.7 | 25 | 2.7 | |
| **Unidentified Pinniped[b]** | | | | | |
| **≥160** | 17 | 11.6 | 97 | 11.6 | |
| **≥170** | 9 | 8.3 | 53 | 8.3 | |
| **≥180** | 5 | 5.1 | 29 | 5.1 | |
| **≥190** | 3 | 2.7 | 16 | 2.7 | |

[a] These density estimates are presented in Appendix Table I.1

[b] Includes Pacific walrus and bearded seal (see text in Chapter 5 for details).

TABLE 5.10. Estimated numbers of individuals exposed and mean numbers of exposures for each individual cetacean during CPAI seismic operations in the Chukchi Sea during 2006. Estimated numbers that might have been exposed to received levels of sounds at various levels are shown. Requested takes for the Chukchi Sea are also shown. Estimates are based on "corrected" densities of cetaceans calculated from sighting effort during the 2006 surveys (see text in Chapter 5) for species-specific estimates).

| | **Based on Non-seismic density[a]** | | **Based on Seismic density[a]** | | |
|---|---|---|---|---|---|
| **Exposure level in dB re 1µPa (rms)** | **Individuals** | **Exposures per Individual** | **Individuals** | **Exposures per Individual** | ***Requested Take*** |
| **≥160** | 170 | 11.6 | 13 | 12.1 | 190 |
| **≥170** | 94 | 8.3 | 7 | 8.9 | |
| **≥180** | 50 | 5.1 | 4 | 5 | |
| **≥190** | 29 | 2.7 | 2 | 3 | |

[a] These density estimates are presented in Appendix Table I.1

The number of different exposures of seals and walruses to levels ≥160 dB (rms) calculated from sighting rates during non-seismic periods, was approximately 11.6 times the number of individual animals exposed, suggesting that each animal was exposed 11.6 times. The repeated exposure of individuals was a result of the fact that many areas were ensonified repeatedly to ≥160 dB as the seismic vessel moved back and forth along different seismic lines. Most animals that lingered in the area would have been exposed to levels ≥160 dB numerous times over an extended period if they did not move away from the source as it approached them, but the number of different individuals exposed in this manner would be far less than the estimated number of exposure incidents.

(*B) ≥170 dB (rms):* If the disturbance criterion for seals is considered to be ≥170 dB (rms), then the estimated number of exposures would be ~40% of the corresponding estimates for ≥160 dB (rms), based on the proportionally smaller areas exposed to ≥170 dB (Table E.2). Overall, there would have been ~6,824 seals and 193 walurses each exposed ~8.3 times to seismic sounds ≥170 dB (Table 5.9).

*(C) ≥180 dB (rms):* Some pinnipeds no doubt were within the 180 dB radius (estimated as being up to 1.75 km, Table 4.1) around the operating airguns but were missed by the observers even during airgun operations conducted in good visibility conditions. It was estimated that there were 5.1 exposures to each of 3,653 individual seals and 103 individual walruses to sounds ≥180 dB (Table 5.9). These figures assume that there was no effective avoidance by pinnipeds of the 180 dB radius around the approaching airguns.

(*D) ≥190 dB (rms):* Based on densities calculated from sighting rates during non-seismic periods, we estimated that there would have been 2.7 exposures to each of 2,095 different seals and 59 different walruses to airgun sounds at ≥190 dB (rms) if there was no avoidance of the seismic vessel (Table 5.9). Even the smaller of these estimates is higher than the number of seals (*n* = 42), walruses (n = 19), and unidentified pinnipeds (n = 1) that direct observations indicated were possiblyexposed to ≥190 dB (see section *Estimates from Direct Observations*). Some pinnipeds within the 190 dB radius presumably were missed during times when MMOs were on watch as well as at night when MMOs generally were not on watch. Even during times when MMOs were on watch, some seals at the surface were likely missed due

to brief surface times, poor visibility, rough seas, and other factors related to sightability. Because of this, density-based estimates of exposures and exposed individuals were higher than those based on direct observation. However, estimates based on densities during non-seismic periods are likely to be overestimates. The chase vessel might be expected to displace some pinnipeds from the trackline before the *Patriot* arrived, and some additional pinnipeds likely swam away in response to the approaching the *Patriot* to avoid exposure to strong seismic sound. Therefore, the actual number exposed to ≥190 dB rms was probably lower than the above estimates.

*Estimates Based on Densities during Seismic Periods:* The estimates quoted in the above paragraphs are all based on densities recorded during non-seismic periods. Densities of seals recorded during seismic periods were lower than those recorded during non-seismic, but densities of unidentified pinnipeds recorded during seismic were markedly higher than those during non-seismic periods (Table I.1). Lower densities might be expected during seismic periods, either because of displacement (to the extent it occurs) or the tendency of seismic activity to take place further away from pack ice where Arctic pinnipeds tend to concentrate in summer. On the other hand, locally abundant food resources near seismic track lines may be responsible for patchy walrus distribution and for occasional high densities in the open water areas where the seismic activities occurred. On several occasions the *Patriot* passed through very strong tide rips and fronts. These areas frequently contain prey biomass higher than surrounding areas and thus attract seals (Suryan and Harvey 1998). The numbers of exposures per individual and minimum numbers of individuals exposed, based on the corrected densities recorded during seismic periods, are summarized in Table 5.9.

Overall, these minimum figures based on densities during seismic periods are somewhat lower than those based on densities during non-seismic periods. Again, the minimum estimates of the numbers of individuals exposed are lower than the minimum estimates of numbers of exposures to various received levels. In other words, some of the individual pinnipeds exposed to a given sound level were exposed to that level multiple times. This reflects the degree of overlap in the ensonified areas around different seismic lines.

***Cetaceans***.—The estimated numbers of cetaceans that might have been exposed to various levels of received sounds, relative to the number of "takes" requested in the IHA application, are summarized in Table 5.10. The density data used to calculate these numbers, for non-seismic as well as seismic periods, are presented in Table I.1. Note that the estimated numbers in Table 5.10 represent the cetaceans that would have been exposed had the animals not shown localized avoidance of the airguns or the ship itself. Many of the animals calculated (based on density) to be within the ≥180 or ≥190 dB zones would in fact have moved away before being exposed to sounds ≥180 or ≥190 dB. This is presumably at least part of the reason for the fact that estimates based on sightings during seismic periods (Table 5.10) were much lower than those during non-seismic periods (Table 5.10).

*(A) ≥160 dB (rms):* We estimate that 170 individual cetaceans would each have been exposed ~11.6 times to airgun pulses with received levels ≥160 dB (rms) during the survey if all cetaceans showed no avoidance of the seismic vessel (Table 5.10). Based on the available densities, 57 of the individuals would have been bowhead whales, 43 gray whales, 1 minke whale 16 unidentified whales, 41 harbor porpoises, and 15 unidentified dolphins (likely beluga whales or harbor porpoises). Minimum estimates of the numbers of different individuals exposed to ≥160 dB were lower than were the estimated number of individual exposures to that level. This reflects the overlap in the ensonified areas around different seismic lines, and the fact that an animal remaining in the area would have been exposed repeatedly to ≥160 dB.

*(B) ≥170 dB (rms):* On average, some odontocete species may be disturbed only if exposed to received levels of airgun sounds ≥170 dB (rms). If so, then the estimated number of exposures would be ~40% of the corresponding estimates for ≥160 dB, based on the proportionally smaller areas exposed to ≥170 dB. Overall, there would have been ~94 individual cetaceans would have each been exposed ~8.3 times to seismic sounds ≥170 dB (Table 5.10).

*(C) ≥180 dB (rms):* If there was no avoidance of airgun noise by cetaceans, it was estimated that there would have been ~5.1 exposures to each of ~50 individual cetaceans to seismic sounds ≥180 dB (Table 5.10). However, most of these cetaceans probably moved away before the airguns were close enough to create a received level ≥180 dB. As noted earlier, there was only 4 cetacean sightings from the *Patriot* when airguns were operating. It is possible that some additional cetaceans were present within the 180 dB radius and not seen by the MMOs during good visibility conditions. However, under those conditions, most cetaceans present probably were seen.

*Estimates Based on Densities during Seismic Periods:* Only the bowhead whale had useable sightings sufficient for the calculation of a density applicable to periods of seismic activity (Table I.1). However, these data are not sufficient for direct comparison of distributions of animals during seismic and non-seismic periods. Based on the corrected densities recorded during seismic periods, the minimum numbers of exposures and minimum numbers of individuals exposed are summarized in Table 5.10B.

# 6. ACKNOWLEDGEMENTS

We thank all of the marine mammal observers (MMOs)—biologists, Inupiat, and CPAI—who participated in the project. W. John Richardson's editing, comments, and knowledge were invaluable in the production of this report. We thank the captains and crews of the *Western Patriot*, the *Torsvik*, the *Gulf Provider*, and the *Peregrine* for their support during the cruises. Additionally, we appreciate the help of John Davis and his team at WesternGeco and Jeff Hastings, Tom Ainsworth and their group at Fairweather. We also thank representatives of the National Marine Fisheries Service, U.S. Fish & Wildlife Service, North Slope Borough Department of Wildlife Management, Alaska Eskimo Whaling Commission and Minerals Management Service for their advice and comments during the "open-water meetings" convened by NMFS in April and October 2006 and at various other times. Caryn Rea, Bruce St. Pierre, Jim Darnall, Mike Faust, and Randy Boyer at CPAI provided support during the project.

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# APPENDIX A:
# INCIDENTAL HARASSMENT AUTHORIZATION ISSUED TO CPAI BY THE NMFS FOR MARINE SEISMIC EXPLORATION ACTIVITIES IN THE CHUKCHI AND BEAUFORT SEAS, 2006

DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL MARINE FISHERIES SERVICE

Incidental Harassment Authorization

Conoco Phillips Alaska, Inc.is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (16 U.S.C. 1371 (a)(5)(D)) and 50 CFR 216.107, to harass small numbers of marine mammals incidental to conducting a marine seismic survey program in the Chukchi Sea in Arctic Ocean waters under the jurisdiction of the United States, contingent upon the following conditions:

1. This Authorization is valid from the date of this Authorization through December 31, 2006.

2. This Authorization is valid only for activities (including support vessels and aircraft)associated with the M/V Patriot conducting seismic survey programs in the Chukchi Sea, asspecified in Conoco's January 30, 2006 application.

3. (a) The species authorized for takings, by Level B Harassment only, are: Bowhead whales (*Balaena mysticetus*), gray whales (*Eschrichtius robustus*), beluga whales (*Delphinapterus leucas*), ringed seals (*Phoca hispida*), spotted seals (*Phoca largha*), and bearded seals (*Erignathus barbatus*).

(b) The taking of any marine mammal in a manner prohibited under this Authorization must be reported within 24 hours of the taking to the Alaska Regional Administrator (907- 586-7221) or his designee in Anchorage (907-271-3023), NMFS and the Chief of the Permits, Conservation and Education Division, Office of Protected Resources, NMFS, at (301) 713-2289, ext 110, or his designee.

4. The holder of this Authorization is required to cooperate with the National Marine Fisheries Service and any other Federal, state or local agency monitoring the impacts of the activity on marine mammals. The holder must notify the Chief of the Permits, Conservation and Education Division, Office of Protected Resources at least 48 hours prior to the start of collecting seismic data (unless constrained by the date of issuance of this Authorization in which case notification shall be made as soon as possible) and whenever not conducting seismic for more than 48 hours.

5. Prohibitions

(a) The taking, by incidental Level B harassment only, is limited to the species listed under condition 3(a) above. The taking by Level A harassment, serious injury, or death of these species or the

taking by behavioral harassment, injury or death of any other species of marine mammal is prohibited and may result in the modification, suspension or revocation of this Authorization.

(b) The taking of any marine mammal whenever the required seismic vessel marine mammal observer (condition 7(a)(i)) is not underway in conformance with condition 7(a)(i), or the coastal or offshore aerial, and/or the dedicated vessel and passive acoustic monitoring programs have not been fully implemented as required by this Authorization is prohibited.

(c) The taking of any marine mammals by seismic sounds when the seismic vessel is within 15 miles of another operating seismic vessel is prohibited.

(d) In accordance with the U.S. Fish and Wildlife Service stipulations (i) seismic surveys are not permitted within the Ledyard Bay spectacled eider critical habitat area; and (ii) seismic-survey support aircraft must avoid overflights of Ledyard Bay critical habitat area after July 1, unless aircraft were at an altitude in excess of 1,500 feet or human safety requires deviation (e.g. a medical emergency).

6. Mitigation.

(a) General Mitigation: The holder of this Authorization is required to:

(i) (A) Avoid concentrations or groups of whales by all vessels and aircraft under the direction of Conoco. Operators of support vessels and aircraft should, at all times, conduct their activities at the maximum distance possible from such concentrations of whales. Under no circumstances, other than an emergency, should aircraft operate at an altitude lower than 1,000 feet when within 500 lateral yards of groups of whales. Helicopters may not hover or circle above such areas or within 500 lateral yards of such areas; and (B) When weather conditions do not allow a 1,000-ft flying altitude, such as during severe storms or when cloud cover is low, aircraft may be operated below the 1,000-foot altitude stipulated above. However, when aircraft are operated at altitudes below 1,000 feet because of weather conditions, the operator must avoid known whale concentration areas and should take precautions to avoid flying directly over or within 500 yards of groups of whales.

(ii) take every precaution to avoid harassment of whale concentrations when a vessel is operated near these animals. Vessels must reduce speed when within 300 yards of whales and vessels capable of steering around such groups must do so. Vessels may not be operated in such a way as to separate members of a group of whales from other members of the group.

(iii) avoid multiple changes in direction and speed when within 300 yards of whales. In addition, operators should check the waters immediately adjacent to a vessel to ensure that no whales will be injured when the vessel's propellers (or screws) are engaged.

(iv) operate small boats at a speed that would make collisions with whales unlikely.

(v) when weather conditions require, such as when visibility drops, vessels must adjust speed accordingly to avoid the likelihood of injury to whales.

(vi) operate in full compliance with the agreed-upon Conflict Avoidance Agreement.

(b) Seismic Vessel Mitigation: The holder of this Authorization is required to:

(i) Reduce the volume of the airgun array during vessel turns while running seismic lines.

(ii) To the extent practical, whenever a marine mammal is detected outside the exclusion zone radius, and based on its position and motion relative to the ship track is likely to enter the safety radius, an alternative ship speed or track will be calculated and implemented.

(iii) Exclusion and Monitoring-Safety Zones:

(A) Establish and monitor with trained observers a preliminary exclusion zone for cetaceans surrounding the airgun array where the received level would be 180 dB re 1 :Pa rms. For purposes of the field verification test, described in condition radius is estimated to be 0.85 km from the seismic source.

(B) Establish and monitor with trained observers a preliminary exclusion zone for pinnipeds surrounding the Bolt seismic airgun array where the received level would be 190 dB re 1 :Pa rms. For purposes of the field verification test this radius is estimated to be 0.23 km from the seismic source.

(C) Immediately upon completion of data analysis of the field verification measurements required under establish and monitor new 180-dB and 190-dB marine mammal exclusion zones.

(D) Cetacean Monitor (Safety) Zones:

(1) Whenever the support "chase" vessel monitoring program described in condition 7(b) below detects an aggregation of 12 or more non-migratory balaenopterid whales within an acoustically verified 160-dB rms zone ahead of, or perpendicular to, the seismic vessel track, the holder of this Authorization must: (a) Immediately power-down the seismic airgun array and/or other acoustic sources to ensure that sound pressure levels atthe shortest distance to the aggregation do not exceed 160 dB rms; and (b) Refrain from powering up the seismic airgun array until biological observers on board the support "chase" vessel(s) or survey aircraft confirm that no balaenopterid aggregations have been detected within the 160-dB zone based upon ship course, direction and distance from last sighting and the last aggregation sighting;

(2) Whenever the aerial monitoring program cow/calf pairs within an acoustically-verified 120-dB monitoring zone, the holder of this Authorization must: (a) Immediately power-down or shut-down the seismic airgun array and/or other acoustic sources to ensure that sound pressure levels are reduced by at least 50 percent; and (b) Refrain from ramping up the seismic airgun array until two consecutive aerial or support vessel surveys confirm that there are no more than 3 bowhead cow/calf pairs within the area to be seismically surveyed within the next 24 hours.

(3) (a) If an aerial monitoring program cannot be implemented due to human safety concerns and vessel surveys are used to monitor the 120-dB monitoring zone as described in a dedicated passive acoustic monitoring program that is capable of locating the position of the vocalization, must be employed and monitored at all times that seismic is operating on the vessel.

(b) If the passive acoustic system detects one or more bowhead vocalizations within the 120-dB zone, the holder of this Authorization must: (a) Immediately shut-down the seismic airgun array and/or other acoustic sources; and (b) not proceed with ramping up the seismic airgun array until the passive acoustic monitoring program confirms that bowhead whales are not within the eastern portion of the 120-dB zone ahead of the ship's trackline over the next 24 hours.

(iv) Power-down/Shut-down.

(A) Immediately shut-down or power-down the seismic airgun array and/or other acoustic sources, whenever any cetaceans are sighted approaching close to or within the area delineated by the 180 dB (re 1:Parms) isopleth, or pinnipeds are sighted approaching close to or within the area delineated by the 190 dB re 1 :Pa rms isopleth established under condition 6(b)(iii).

(B) Not proceed with ramping up the seismic airgun array unless the safety zones described in condition 6(b)(iii) are visible and no marine mammals are detected within the appropriate safety zones; or until 15 minutes (for small odontocetes, pinnipeds) or a minimum of 30 minutes (for mysticetes/large odontocetes) after there has been no further visual detection of the animal(s) within the safety zone and the trained marine mammal observer on duty is confident that no marine mammals remain within the appropriate safety zone.

C) Emergency shut-down. If observations are made or credible reports are received that one or more marine mammals are within the area of the seismic survey are in an injured or mortal state, or are indicating acute distress due to seismic noise, the seismic airgun array will be immediately shut down and the Chief of the Permits, Conservation and Education Division, Office of Protected Resources or a staff member contacted. The airgun array will not be restarted until review and approval has been given by either the Alaska Regional Administrator or the Director, Office of Protected Resources or their designees.

(v) Ramp-up

(A) Prior to commencing ramp-up described in condition 6 (b)(v)(C), conduct a 30-minute period of marine mammal observations by at least one trained marine mammal observer (1) at the commencement of seismic operations and (2) at any time electrical power to the airgun array is discontinued for a period of 10 minutes or more and the marine mammal observer watch has been suspended;

(B) If the safety radii are not completely visible for at least 30 minutes prior to ramp-up in either daylight or nighttime, do not commence rampup unless the seismic source has maintained a sound pressure level of at least 180 dB re 1 :Pa rms during the interruption of seismic survey operations.

(C) If the complete 180 dB safety range is visible and no marine mammals are observed while undertaking pre-ramp-up monitoring under conditions 6(b)(v)(A) and (B), ramp-up airgun arrays at a rate no faster than approximately 6 dB per 5-minute period starting with the smallest airgun in the array and then adding additional guns in sequence, until the full array is firing: (1) At the commencement of seismic operations, and (2), anytime after the airgun array has been powered down for more than 10 minutes;

(D) Do not proceed with ramp-up whenever the entire 180 dB safety zone is not visible and more than 2 power-downs due to marine mammal presence within the 180 dB safety zone had occurred within the past 12 hours.

7. Monitoring.

(a) Seismic Vessel Monitoring

(i) The holder of this Authorization must designate biologically-trained, on-site marine mammal observers (MMOs) to be onboard the *M/V Patriot*, and designated support vessels conducting marine mammal observations or surveys, approved in advance by National Marine Fisheries Service (one may be an Inupiat), to conduct the visual monitoring programs required under this Authorization and to record the effects of seismic surveys and the resulting noise on marine mammals. The minimum number of MMOs required are:

(A) Between July 15th and September 15th, there must be at least 4 trained MMOs (one may be an Inupiat) aboard each source vessel at any one time during all seismic operations.

(B) Between September 16 and the end of the survey, there must be at least 3 MMOs onboard each source vessel at any time during all seismic operations.

(ii) MMOs must not be on duty for more than 4 consecutive hours, although more than one 4-hour shift per day is acceptable.

(iii) MMOs will monitor to: (A) ensure that no marine mammals enter the appropriate safety zone whenever the seismic array is on, and (B) record marine mammal activity as described in condition 7(f) below. At least two observers must be on watch during ramp ups and the 30 minutes prior to full ramp ups, and for as large a fraction of the other operating hours as possible. At all other times, at least one observer must be on active watch whenever the seismic airgun array is operating during all daytime airgun operations, during any nighttime power-ups of the airguns and at night, whenever that day's monitoring resulted in one or more power-downs due to marine mammal presence.

(iv) The crew also must be instructed to keep watch for marine mammals at all times. If any are sighted, the bridge watch-stander must immediately notify the MMO on-watch.

(v) Observations by the MMOs on marine mammal presence and activity will begin a minimum of 30 minutes prior to the estimated time that the seismic source is to be turned on and/or ramped-up.

(vi) MMOs will record the following: (A) the species, group size, age/size/sex categories (if determinable), the general behavioral activity, heading (if consistent), bearing and distance from seismic vessel, sighting cue, behavioral pace, and apparent reaction of all marine mammals seen near the seismic vessel and/or its airgun array (e.g., none, avoidance, approach, paralleling, etc) and; (B) the time, location, heading, speed, and activity of the vessel (shooting or not), along with sea state, visibility, cloud cover and sun glare at (1) any time a marine mammal is sighted, (2) at the start and end of each watch, and (3) during a watch (whenever there is a change in one or more variable); and, (C) the identification of all vessels that are visible within 5 km of the seismic vessel whenever a marine mammal is sighted, and the time observed, bearing, distance, heading, speed and activity of the other vessel(s).

(vii) All MMOs must be provided with and use appropriate night-vision devices, Big Eyes, and reticulated and/or laser range finding binoculars.

(b) Chase Boat Monitoring

(i) At least one "chase boat" will assist in monitoring safety and monitoring zones during active seismic survey operations. The chase boat will have at least two MMOs onboard to collect marine mammal observations.

(ii) During all active seismic survey activity, the chase boat will conduct marine mammal surveys no less than every 48 hours or 3 times per 7 days, of the 160-dB area to be seismically surveyed over the next 24 hours. MMOs will search for aggregations of bowhead and gray whale feeding utilizing a survey design approved in advance by the National Marine Fisheries Service.

(iii) The MMOs on the chase boat will immediately contact the seismic survey ship if marine mammals are sited within the 180/190-dB safety zone or aggregations of 12 or more non-migratory bowhead whales or gray whales are sited within the surveyed 160-dB zone.

(iv) The MMOs onboard chase boats will be limited to shifts of 4 hrs in length and 12 hrs total in a 24 hr period.

(c) Aerial Surveys

(i) In addition to the coastal aerial monitoring program mentioned in condition 8(a)(ii), the holder of this Authorization must implement an aerial monitoring program in the Chukchi Sea upon the earliest of the following conditions: (i) the research vessel monitoring program mentioned in condition 8(a)(iii) has detected 4 migratory cow/calf pairs at the surface during a vessel transit (ii) bowhead whale hunters have determined that the "pulse" of cow/calf pairs are passing Barrow AK in significant numbers (and NMFS has been so notified by the Alaska Eskimo Whaling Commission) or (iii) September 25, 2006.

(ii) Once initiated, aerial monitoring will take place daily (weather permitting), concentrating on the area (A) ahead of the vessel track, (B) upstream of bowhead whale migration, and (C) east of the vessel, whenever Conoco's seismic vessel is conducting seismic surveys and is operating within an area of the Chukchi Sea that can be aerially surveyed safely.

(iii) If the biological observers onboard the aircraft see 4 or more migratory bowhead whale cow/calf pairs within the surveyed portion of the 120-dB isopleth from the seismic survey vessel, the lead observer of his/her designee will contact the MMO on watch onboard the seismic vessel of the observation. The location, bearing and approximate speed of the migratory bowhead whales will be recorded.

(iv) Following the suspension of seismic surveys after sighting 4 or more migratory cow/calf pairs, aircraft surveys should initiate new surveys in the area surveyed the previous day.

(d) Field Source Verification Using an autonomous ocean bottom hydrophone system, the Holder of this Authorization is required to measure and report on the distances from the airgun array to broadband received levels of 190, 180, 170, 160, and 120 dB (rms) re 1 Pa. at the beginning of the survey in the Chukchi Sea.

8. Research

(a) The holder of the Authorization, in cooperation with other Authorization holders conducting seismic surveys in the Chukchi Sea during 2006, must conduct all research described in the "Final Monitoring Plan for Seismic Exploration in the Alaskan Chukchi Sea, 2006." Monitoring will include establishment of:(i) an acoustic program to measure sounds produced by seismic vessels (required under condition 7(e)), (ii) an aerial monitoring and reconnaissance of marine mammals available for subsistence harvest along the Chukchi Sea coast; (iii) research ship surveys of the Chukchi Sea, including a towed hypdrophone passive acoustic monitoring system to collect data on the distribution and abundance of marine mammals; and (iv) deployment, and later analysis of data from, bottom-founded autonomous acoustic recorder arrays along the coast of the Chukchi Sea to record ambient sound levels, vocalizations of marine mammals, and received levels of seismic operations should they be detectable.

9. Reporting.

(a) Field Source Verification and the distances to the various radii are to be reported within 72 hours of completing the measurements. In addition to reporting the radii of specific regulatory concern, distances to other sound isopleths down to 120 dBrms (if measurable) will be reported in increments of 10 dB.

(b) Seismic Vessel Monitoring Program: A draft report will be submitted to the National Marine Fisheries Service within 90 days after the end of Conoco's seismic survey program in the Arctic Ocean. The report will describe in detail (i) the operations that were conducted, (ii) the results of the acoustical measurements to verify the safety radii, (iii) the methods, results, and interpretation pertaining to all monitoring tasks; (iv) the results of the 2006 shipboard marine mammal monitoring;; (v), a summary of the dates and locations of seismic operations, including summaries of power downs, shut downs, and ramp up delays; (vi) marine mammal sightings (species, numbers, dates, times and locations; age/size/gender, environmental correlates, activities, associated seismic survey activities), (vii) estimates of the amount and nature of potential take (exposure) of marine mammals (by species) by harassment or in other ways to industry sounds; (viii) an analysis of the effects of seismic operations (e.g., on sighting rates, sighting distances, behaviors, movement patterns of marine mammals); (ix) provide an analysis of factors influencing detectability of marine mammals; and (x) provide summaries on communications with hunters and potential effects on subsistence uses.

(c) The draft report will be subject to review and comment by the National Marine Fisheries Service. Any recommendations made by the National Marine Fisheries Service must be addressed in the final report prior to acceptance by the National Marine Fisheries Service. The draft report will be considered the final report for this activity under this Authorization if the National Marine Fisheries Service has not provided comments and recommendations within 90 days of receipt of the draft report.

(d) A draft comprehensive report describing the acoustic, vessel-based, and aerial monitoring programs will be prepared and submitted within 240 days of the effective date of this Authorization. The comprehensive report will describe the methods, results, conclusions and limitations of each of the individual data sets in detail. The report will also integrate (to the extent possible) the studies into a broad based assessment of all industry activities and their impacts on marine mammals in the Arctic Ocean during 2006.

(e) The draft comprehensive report will be reviewed by participants at the 2007 Open Water Scientific Meeting to be held in Anchorage AK in April, 2007. The draft comprehensive report will be

accepted by the National Marine Fisheries Service as the final comprehensive report upon incorporation of recommendations by the workshop participants.

10. Activities related to the monitoring described in this Authorization do not require a separate scientific research permit issued under section 104 of the Marine Mammal Protection Act.

11. The Plan of Cooperation/Conflict Avoidance Agreement outlining the steps that will be taken to cooperate and communicate with the native communities to ensure the availability of marine mammals for subsistence uses, must be implemented.

12. A copy of this Authorization must be in the possession of the operator of all vessels and aircraft engaging in the activity operating under the authority of this Incidental Harassment Authorization.

_____ _____

James H. Lecky Date
Director, Office of Protected Resources
National Marine Fisheries Service

cc: PR; PR1, PR1-Ken Hollingshead
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PR1- KRHollingshead, 301-713-2289xt. 128.

# APPENDIX B:
# INCIDENTAL HARASSMENT AUTHORIZATION ISSUED TO CPAI BY THE USFWS FOR MARINE SEISMIC EXPLORATION ACTIVITIES IN THE CHUKCHI AND BEAUFORT SEAS, 2006

AFES/MMM

Mr. Bruce St. Pierre
Senior Environmental Coordinator
ConocoPhillips Alaska
P.O. Box 100360
Anchorage, Alaska 99510-0360

Dear Mr. St. Pierre:

This responds to your request dated, February 15, 2006 for an incidental take authorization (IHA) for the incidental take of polar bears and Pacific walrus in the Chukchi Sea in association with the 2006 ConocoPhillips Alaska, Inc. (CPAI) open-water geophysical (seismic) program. This letter is to transmit the final IHA and its relevant operational conditions, monitoring and reporting requirements to CPAI.

This incidental take authorization is issued in accordance with provisions of the Marine Mammal Protection Act, as amended, described in the USFWS publication listed at 71 FR 26770, dated May 8, 2006. Should you have any further questions contact Mr. Craig Perham of our Marine Mammals Management Office at (907) 786-3800 or 786-3810.

Sincerely,

Thomas Melius
Regional Director

Enclosure

cc: FFWFO
LE
Rance Wall, Minerals Management Service

MMM

ISSUED: June 29, 2006
EXPIRES: November 30, 2006

# INCIDENTAL TAKE AUTHORIZATION
# (IHA-06-02)

ConocoPhillips Alaska, Inc. is hereby authorized to take small numbers of polar bears and Pacific walrus incidental to conducting oil and gas exploration activities in the Chukchi Sea identified within your IHA request (February 15, 2006). This IHA (IHA-06-02) allows ConocoPhillips Alaska, Inc. (CPAI), to take small numbers of Pacific walrus and polar bears incidental to oil and gas exploration activities in association with the Chukchi Sea open-water geophysical (seismic) program. A description of the project is presented in 71 FR 26770.

Authorization is subject to the following conditions:

1. The polar bear/walrus interaction plan is approved and all provisions unless noted specifically are incorporated into the IHA by reference.

2. The Operations Manager will be fully aware, understand, and capable of implementing the conditions of this authorization.

3. Intentional take is prohibited.

4. This authorization is valid only for those activities identified in the request for an IHA dated February 10, 2006.

5. Conditions that will be required to minimize the potential for harassment include the following:
(1) Seismic and support vessels must observe a 0.5-mile (800-m) exclusion zone around walrus and polar bears observed on land or ice during travel status.

   (2) Aircraft will be required to maintain a 1,000-ft (300-m) minimum altitude within 0.5 mile (800-m) of hauled out walrus and polar bears.

   (3) Seismic operations will cease if walrus or polar bears are sighted within a 190 dB acoustical safety radius.

   (4) Ice management mitigation measures, i.e., ‘‘ice scouting,’’ such as radar, satellite imagery, and reconnaissance flights using scheduled aircraft to monitor ice movement in the projected survey areas 24 to 48 hours prior to seismic activity, should be considered in response to ice movement. They will serve to limit the distance to ice due to seismic program protocols and thus limit the potential for walrus and polar bear encounters.

6. No seismic activities will occur within a 40-mile radius of affected communities. This condition will limit potential interactions with walrus hunters in near-shore environments.

7. Polar bear and walrus monitoring, reporting, and survey activities will be conducted in accordance with those outlined in 71 FR 26770. The basic monitoring and reporting requirements follow:

   " Cooperate with the Fish and Wildlife Service, and other designated Federal, State, or local agencies to monitor the impacts of oil and gas seismic activities on polar bears and Pacific walrus;

   " A Service-approved site-specific polar bear and walrus interaction plan will be on file with the USFWS and on-site for company personnel. These plans outline the contingency steps that the applicant will take, such as the chain of command for reporting and responding to polar bear or walrus sightings.

   " Designate a qualified individual or individuals to observe, record, and report the effects of the activity on Pacific walrus and polar bears; a FWS-approved monitoring plan requires ship-board trained marine mammal observers. During seismic operations, on-board marine mammal observers will monitor the zone of ensonification for polar bears and walrus. If a polar bear or walrus is sighted in the ensonification zone, operations will cease until animals move out of the zone.

   " At the discretion of the Fish and Wildlife Service, allow the Fish and Wildlife Service to place an observer on the site (vessels and aircraft) to monitor the impacts of the activity on Pacific walrus and polar bears;

   " Report all observations of Pacific walrus and polar bears to the Marine Mammals Management Office, Fish and Wildlife Service within 48 hours;

   " Submit a report to the Marine Mammals Management Office within 90 days after completion of activities.

8. This authorization expires November 30, 2006.

_____ _____

Chief, Marine Mammals Management Date

# APPENDIX C:
## DEVELOPMENT AND IMPLEMENTATION OF SAFETY RADII

This appendix provides additional background information on the development and implementation of safety radii as relevant to the SOI seismic exploration activities discussed in this report. It is not known whether exposure to a sequence of strong pulses of low-frequency underwater sound from marine seismic exploration actually can cause hearing impairment or non-auditory injuries in marine mammals (Richardson et al. 1995:372*ff*; Finneran et al. 2002). There has been considerable speculation about the potential for injury to marine mammals, based primarily on what is known about hearing impairment to humans and other terrestrial mammals exposed to impulsive low-frequency airborne sounds (e.g., artillery noise). The 180-dB criterion for cetaceans was established by NMFS (1995) based on those considerations, before any data were available on temporary threshold shift (TTS) in marine mammals. NMFS (1995, 2000) concluded that there are unlikely to be any physically-injurious effects on cetaceans exposed to received levels of seismic pulses up to 180 dB re 1 µPa root-mean-square (rms). The corresponding NMFS criterion for pinnipeds is 190 dB re 1 $\mu Pa_{rms}$.

Finneran et al. (2002) have found that the onset of mild TTS in a beluga whale (odontocete) exposed to a single watergun pulse occurred at a received level of 226 dB re 1 µPa pk-pk and a total energy flux density of 186 dB re 1 $\mu Pa^2 \cdot s$. The corresponding rms value for TTS onset upon exposure to a single watergun pulse would be intermediate between these values. It is assumed (though data are lacking) that TTS onset would occur at lower received pressure levels if the animals received a series of pulses. However, no specific results confirming this are available yet. On the other hand, the levels necessary to cause injury would exceed, by an uncertain degree, the levels eliciting TTS onset.

The above-mentioned 180 dB re 1 µPa level is measured on an rms basis. The rms pressure is an average over the duration of the seismic pulse (Greene 1997; Greene et al. 1998). This is the measure commonly used in recent studies of marine mammal reactions to airgun sounds. The rms level of a seismic pulse is typically about 10 dB less than its peak level (Greene 1997; McCauley et al. 1998, 2000a,b). Rms level is affected by duration of the received pulse, which depends on propagation effects between the source and the receiving animal. The greater the temporal dispersion of (i.e., the longer) the received pulse, the lower the expected rms level. Biological effects probably are more closely related to energy content of the received pulse than to its rms pressure, but we consider rms pressure because current NMFS criteria are based on that method.

Radii within which received levels from the airgun array were expected to diminish to various values relevant to NMFS criteria mentioned above were estimated by CPAI. Prior to entering the Chukchi Sea, CPAI contracted with JASCO to model the sound source characteristics using JASCO's airgun array source model (to estimate the source and near-field properties) and JASCO's implementation of a parabolic equation model to predict received levels at various distances in each direction. The models, in combination, account for airgun array characteristics, bathymetry effects, water properties, and the geoacoustic properties of seabed layers. JASCO's modeling procedures and results are summarized in Chapter 3. Empirical data to determine actual sound levels produced by the airgun array were obtained shortly after the *Western Patriot* entered the Chukchi Sea and new radii based on these measurements are reported in Chapter 4. In all comparisons measured radii were greater than radii estimated by either of the two modeling programs.

The radius at which received levels diminish to 160 dB re 1 $\mu Pa_{rms}$ is considered by NMFS to be a possible criterion of behavioral disturbance for cetaceans. The data on which this 160 dB criterion is

based pertain to baleen whales, and many of the odontocetes (e.g., pinnipeds) do not appear to be as responsive to seismic sounds as are baleen whales (Richardson et al. 1995; Gordon et al. 2004). In this report, the numbers of all species exposed to ≥160 dB are estimated. However, for certain taxa (e.g., pinnipeds), the 170 dB radius is considered as an alternative and more realistic estimate of the outer bounds of the area within which animals are likely to be disturbed significantly. For those taxa, the numbers exposed to ≥170 dB are also estimated.

# APPENDIX D:
## DESCRIPTION OF VESSELS

### *Vessels*

**M/V *Western Patriot***

CPAI's seismic source vessel, the *Western Patriot*, was built in 1993 and is owned by Seismic Shipping Inc. The port of registry for the *Western Patriot* is Panama. The overall length of the *Western Patriot* is 78 m (256 ft) and the gross tonnage is 3,586 metric tons. The mean draft of the *Western Patriot* is 5.9 m (19 ft). The *Western Patriot* is equipped with a helicopter deck rated for a Super Puma. The fuel capacity of the *Western Patriot* is 1,240 $m^3$ and the fuel consumption rate at full speed is 32 $m^3$ per day. The *Western Patriot* is powered by two Bergen BRM 6 diesel engines and equipped with bow and stern thrusters.

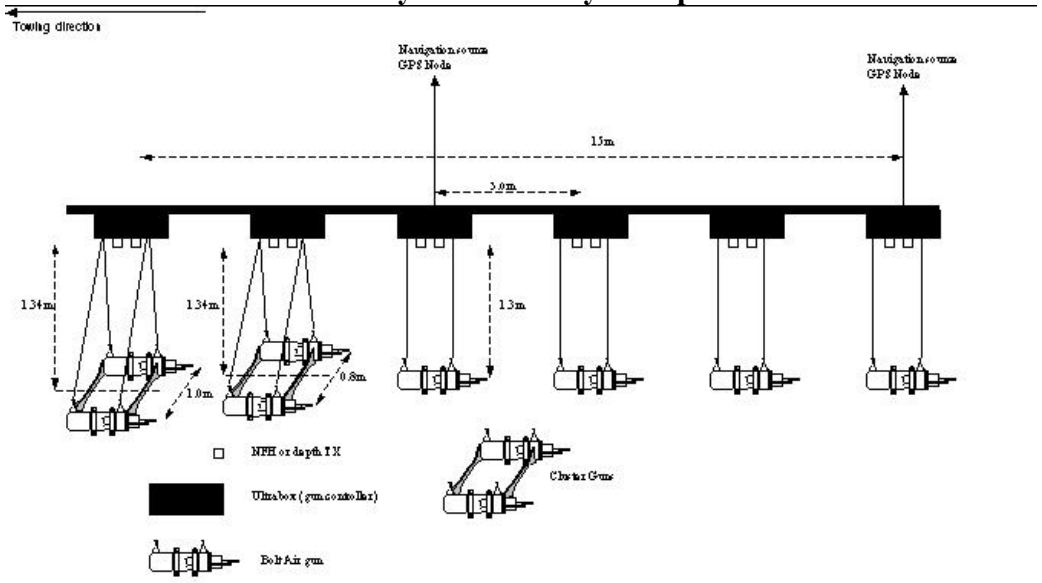
### *Airgun Description and Safety Radii: Western Patriot*

Aboard the *Western Patriot*, CPAI used WesternGeco's 3390 $in^3$ Bolt-Gun Array for its 3–D seismic survey operations in the Chukchi Sea. Two identical 3390 $in^3$ airgun arrays that could be fired alternately were towed behind the *Western Patriot*. Each of the the source arrays on the *Western Patriot* were composed of two identically tuned 1,695 $in^3$ Bolt-Gun sub-arrays operating at 2000 psi air pressure. In general, the signature produced by an array composed of multiple sub-arrays has the same shape as that produced by a single sub-array while the overall acoustic output of the array is determined by the number of sub-arrays employed.

Each sub-array was composed of six tuning elements, two 2-gun clusters (one composed of two 290 $in^3$ gun, the other of two 195 $in^3$ guns), and four single guns ranging in size from 105 to 280 $in^3$. The clusters had their component guns arranged in a fixed side-by-side fashion with the distance between the gun ports set to maximize the bubble suppression effects of clustered guns. A near-field hydrophone was mounted about 1 m above each gun station (one phone was used per cluster), one depth transducer per position was mounted on the gun's ultrabox, and a high pressure transducer was mounted at the aft end of

the subarray to monitor high pressure air supply. All the data from these sensors were transmitted to the vessel for input into the onboard systems and recording to tape.

**Standard 1695 in$^3$ sub-array - 2 sub-arrays comprise the 3390 in$^3$ Source**




Information on the source array was taken from a WesternGeco Source Array Document.

The configuration of a source array for CPAI's 3D seismic surveys consisted of two 1695 in$^3$ subarrays. The sub-arrays were lined up parallel to each other with 10 m cross-line separation between them. This separation was chosen to minimise the areal dimensions of the array in order to approximate point source radiation characteristics for frequencies in the nominal seismic processing band. For the 3390 in$^3$ array the overall dimensions of the array are 15 m long by 10 m wide.

**M/V *Torsvik***

The Torsvik was the primary chase vessel for the Western Patriot during seismic exploration activities in the Chukchi Sea in 2006. The Torsvik was built in Denmark in 1979 and the home port is Hósvík, Faroe Islands. The overall length of the *Torsvik* is 39.2 m (129 ft) and is powered by an 88o Bhp (648 KW) B & W Alpha Diesel, type 408/26V0 engine. The maximum speed of the Torsvik is 12 knots. The Torsvik is equipped with three 55 kW type ECC-BRF-250 generators.

**M/V *Gulf Provider***

The *Gulf Provider* was the primary supply vessel used for transfer of personnel, equipment, and supplies to the *Western Patriot* and the *Torsvik*. On occasion the *Gulf Provider* also served as the *Western Patriot's* chase boat. The *Gulf Provider* was built in Jennings, Louisiana in 1979 and was re-built in 2001. The current port of registry is Panama. The overall length of the *Gulf Provider* is 57.8 m (190 ft) and the gross tonnage is 926 metric tons. The fuel capacity of the *Gulf Provider* is 530 $m^3$ and the fuel consumption rate is 6-10 $m^3$ per day. The *Gulf Provider* is powered by two Caterpillar D-399 diesel engines and is equipped with a waste oil and sludge incinerator.

***R/V Peregrine***

The R/V *Peregrine* is a small (94 ft length by 24 ft beam), jet- and prop-driven, aluminum landing craft with a 0.76 (30 in) draft. The *Peregrine* was powered by three Cummins diesels, of 300 hp each, driving two Kodiak model 403 water jets, and a single four-bladed propeller mounted within a 0.76 (30 in) recess at the stern. The *Peregrine* was used to supply other vessels involved in the seismic survey and transport personnel. It also served as a platform from which vessel-based marine mammal observers watched for marine mammals. The elevated bridge spanned the width of the boat near the stern and afforded good visibility for the observers within almost a 360 degree arc.

# APPENDIX E:
## DETAILS OF MONITORING, MITIGATION, AND ANALYSIS METHODS

This appendix provides details on the standard visual and acoustic monitoring methods and data analysis techniques implemented for this project and previous seismic studies.

Four marine mammal observers (MMOs) were aboard the *Western Patriot* throughout the cruise. The lead MMO was a biologist experienced in marine mammal identification and observation methods. Two MMOs were Inupiats with experience living and hunting in the Arctic. The fourth MMO was supplied by CPAI. In addition to the MMOs onboard the *Western Patriot*, 2 MMOs were on the *Torsvik*. MMOs generally worked a 6-week shift before being replaced by other MMOs during the course of the field season.

All MMOs participated in safety training and a review meeting before the start of the field season, designed to familiarize them with the operational procedures and conditions for the cruise, reporting protocols, and IHA stipulations. In addition, implementation of the IHA requirements was explained to the Operations Manager and Head Airgun Operator aboard the vessel during a meeting prior to seismic operations. MMO duties included

- watching for and identifying marine mammals, and recording their numbers, distances and behavior;
- noting possible reactions of marine mammals to the seismic operations;
- initiating mitigation measures when appropriate; and
- reporting the results.

### *Visual Monitoring for Marine Mammals*

Vessel-based observers monitored marine mammals from the seismic source vessel (*Western Patriot*) during all daytime seismic operations, and during any nighttime start ups of the airgun(s), as specified in the IHA and Federal Register Notice (NMFS 2006b). MMOs onboard the chase vessel (Torsvik and occasionally the Gulf Provider when it served as the chase vessel for the *Western Patriot*) also monitored marine mammals during much of the time that seismic operations were occurring. Seismic operations were suspended or amended when marine mammals were observed within, or about to enter, designated safety zones (see above) where there was a possibility of significant effects on hearing or other physical injury. In general, vessel-based observations for marine mammals were conducted using the following guidelines:

- MMOs on the seismic vessel observed during daylight periods while seismic surveys were conducted and, to a similar or lesser extent determined by the Lead MMO, while the vessel was underway but production activities were not being conducted.
- Two dedicated MMOs observed for 30 min prior to the planned start of seismic operations after an extended shut down.
- When the airgun(s) were started at night, two MMOs watched for marine mammals, using night vision devices, for 30 min prior to start up. (Note that there was 24-hour daylight until late August.)

- The entire safety radius was required to be visible for 30 min prior to start up from a prolonged shutdown during either daylight or nighttime.
- At least one MMO was on stand-by during ongoing seismic operations at night, but was not necessarily on active duty.
- Bridge personnel watched for marine mammals during seismic operations at night and were required to call for the airgun(s) to be shut down if necessary. Bridge personnel also notified the MMO on stand-by if marine mammals were observed in or about to enter the safety radii.
- Observations during daylight hours were conducted in good and poor visibility whenever the airgun(s) were operating and as specified in the IHA, and by two observers if possible, unless safety reasons precluded such observations. During darkness MMOs would be on watch prior to and during ramp-ups observing with NVDs.
- MMOs observed during transit periods without airgun operations, and at the discretion of the Lead MMO, to obtain baseline data on marine mammal distribution and (in the case of less experience observers) to become more familiar with observation protocols and.
- MMOs also recorded locations and movements of vessels when on watch; (information regarding vessels as well as marine mammals was recorded in database).

The MMOs used the bridge of the *Western Patriot* as an observation platform, where the observer's eye level was ~14.2 m above sea level (ASL). When two MMOs were on duty on the bridge simultaneously, they worked on opposite sides of the bridge unless safety or weather conditions precluded such observations.

From the duty station, MMO(s) systematically scanned the area around the vessel in a left to right sweep pattern, usually alternating scan sweeps between reticle binoculars (e.g., Fujinon 7 × 50) and the naked eye during the daytime. Observations were focused and centered forward of the vessel in an arc of ~210º, but MMOs also regularly checked for the presence of marine mammals astern of the vessel. Night vision devices were used during non-daylight hours using a similar sweep search pattern.

MMOs were generally on duty for shifts up to 4 -hr, with a 2–4 hr break between shifts, depending on the number of observers available and the number of daylight hours. Each individual MMO was generally on duty for ~8–-10 hrs per day. The duration of a single visual shift was no longer than 4 hours to minimize observer fatigue. Two MMOs were on watch during the 30 min periods preceding start up of the airgun(s), if possible. Use of two observers simultaneously was desirable and was scheduled when possible to increase detection of marine mammals near the source vessel. In addition to the dedicated MMOs, bridge personnel were instructed and assisted in detecting marine mammals, implementing mitigation requirements, and collecting data as possible before the start of the seismic survey.

While on watch, MMOs kept systematic records of the vessel's position, activity, and environmental conditions using codes that were entered onto tablet PC and later transcribed onto an excel spreadsheet. Data were recorded onto the tablet PC every 30 min. Additional data were recorded when marine mammals were observed. For all records, the date and time, vessel position (longitude and latitude), and environmental conditions were recorded. Environmental conditions were also recorded whenever the conditions changed and with each marine mammal sighting.

The following information was recorded for each marine mammal sighting: species, number of individuals, bearing relative to vessel's heading, direction of movement relative to the vessel, distance from the vessel, vessel position and type of activity, sighting cue, behavior when first sighted, behavior

after initial sighting, behavioral pace, and species identification reliability using the codes on Table E.1. On the seismic vessel, distance to marine mammals was measured from the MMO's location on the

TABLE E.1. List of codes used by MMOs during seismic exploration activities in the Chukchi Sea, 2006.

| | |
|---|---|
| WS | Watch Start |
| WE | Watch End |

**LINE**
Enter Line ID or leave blank

**SEISMIC ACTIVITY**

| | |
|---|---|
| LS | Line Shooting |
| SH | Shooting Between/Off.Lines |
| ST | Seismic Testing |
| SZ | Safety Zone Shut-Down |
| SD | Shut-Down |
| OT | Other (comment and describe) |

**# GUNS**
Enter Number of Operating Airguns, or

| | |
|---|---|
| 88 | Varying (e.g., ramp-up) |
| 99 | Unknown |

**ARRAY VOLUME**
Enter operating volume, or

| | |
|---|---|
| 99 | Unknown |

**(BEAUFORT) SEA STATE**
See Beaufort Scale sheet.

**LIGHT OR DARK**

| | |
|---|---|
| L | Light (day) |
| D | Darkness |

**GLARE AMOUNT**

| | |
|---|---|
| NO | None |
| LI | Little |
| MO | Moderate |
| SE | Severe |

**POSITION**
Clock Position, or

| | |
|---|---|
| 99 | Variable (vessel turning) |

**WATER DEPTH**
In meters

**MARINE MAMMAL SPECIES**

**Baleen Whales**

| | |
|---|---|
| BHW | Bowhead Whale |
| BLW | Blue Whale |
| FW | Fin Whale |
| GW | Gray Whale |
| SW | Sei Whale |
| HW | Humpback Whale |
| MW | Minke Whale |
| UMW | Unidentified **Mysticete Whale** |
| UW | Unidentified Whale |

**Large Toothed Whales**

| | |
|---|---|
| BW | Beluga Whale |
| KW | Killer Whale |
| NW | Narwhal |
| NBW | Northern Bottlenose Whale |
| SPW | Sperm Whale |
| LFPW | Long-finned Pilot Whale |
| UTW | Unidentified Tooth Whale |

**Dolphins**

| | |
|---|---|
| UD | Unidentified Dolphin |

**Porpoises**

| | |
|---|---|
| HP | Harbor Porpoise |

**Pinnipeds**

| | |
|---|---|
| BS | Bearded Seal |
| HBS | Harbor Seal |
| HDS | Hooded Seal |
| HPS | Harp Seal |
| RS | Ringed Seal |
| SS | Spotted Seal |
| US | Unidentified Seal |
| UP | Unidentified Pinniped |
| PWA | Pacific Walrus |

**Carnivora**

| | |
|---|---|
| PB | Polar Bear |

**MOVEMENT**

| | |
|---|---|
| PE | Across Bow |
| ST | Swim Toward |
| SA | Swim Away |
| FL | Flee |
| SP | Swim Parallel |
| MI | Mill |
| NO | No movement |
| DE | Dead |
| UN | Unknown |

**INDIVIDUAL BEHAVIOR**

| | |
|---|---|
| MA | Mating |
| SI | Sink |
| FD | Front Dive |
| TH | Thrash Dive |
| DI | Dive |
| LO | Look |
| LG | Logging |
| SW | Swim |
| BR | Breach |
| LT | Lobtail |
| SH | Spyhop |
| FS | Flipper Slap |
| FE | Feeding |
| FL | Fluking |
| BL | Blow |
| BO | Bow Riding |
| PO | Porpoising |
| RA | Rafting |
| WR | Wake Riding |
| AG | Approaching Guns |
| RE | Resting |
| OT | Other (describe) |
| NO | None (sign seen only) |
| UN | Unknown |

**GROUP BEHAVIOR (BEHAVIORAL STATES)**

| | |
|---|---|
| TR | Travel |
| SA | Surface Active |
| ST | Surface Active-Travel |
| MI | Milling |
| FG | Feeding |
| RE | Resting |
| OT | Other (describe) |
| UN | Unknown |

**# RETICLES or ESTIMATE**
(of Initial Distance, etc.; Indicate Big eyes or Fujinons in comments)

| | |
|---|---|
| 0 to 16 | Number of reticles |
| E | Estimate, by eye |

**SIGHTING CUE**

| | |
|---|---|
| BO | Body |
| HE | Head |
| SP | Splash |
| FL | Flukes |
| DO | Dorsal Fin |
| BL | Blow |
| BI | Birds |

bridge rather than from the nominal center of the seismic source. The distance of the animal from the airgun array was calculated during the analyses. However, for sightings near or within the safety radius in effect at the time, the distance from the marine mammal to the nearest airgun was estimated and recorded for the purposes of implementing power downs or shut downs. The bearing from the vessel to individual or groups of marine mammals was estimated using positions on a clock face, with the bow of the vessel considered to be 12 o'clock and the stern 6 o'clock.

Operational activities that were recorded by MMOs onboard the seismic vessel included the number of airguns in use, total volume of the airguns, and the type of vessel/seismic activity. The position of the vessel was logged every 60 sec by the ships navigational system. These data were copied from an electronic database and pasted into the marine mammal database. Specific information regarding the seismic activities (number of guns and air volume) was collected the gunner's log. Inter-ship communication between seismic technicians and MMOs was conducted via radio or telephone and used to alert MMOs of any changes in operations, and to request power or shut downs by MMOs.

All data were initially recorded on a tablet PC with customized software (Study Participant Ver. 2.0), in the field and were entered into a Microsoft Excel® database at the end of the day. The database was constructed to prevent entry of out-or-range values and codes. Data entries were checked manually by comparing listings of the computerized data with the original handwritten datasheets, both in the field and upon later analyses. Data collected by MMOs were also checked against the navigation and shot logs collected automatically by the vessel's computers.

## *Marine Mammal Mitigation During Operations*

The following mitigation measures were adopted for marine mammal sightings during the proposed seismic program, provided that doing so did not compromise operational safety requirements: course alteration, power downs, shut downs, and ramp ups.

### *Course Alteration*

If a marine mammal was detected outside the safety radius and, based on its position and direction of travel, was likely to enter the safety radius, one possible mitigation measure is to adjust the ship track and/or speed to avoid close approach to the mammal. However, given the presence of the streamer(s) and airgun(s) behind the vessel, the turning rate of the vessel while this gear is deployed is limited, and course alteration is generally not a practical mitigation method for a seismic vessel. Instead, the marine mammal's activities and movements relative to the seismic vessel were closely monitored. If the mammal appeared likely to enter the safety radius, further mitigation actions were taken, i.e., power or shut down of the airgun(s).

### *Power-down Procedures*

If marine mammals were detected outside the safety radius but were likely to enter the safety radius (i.e., if the mammals were moving towards the vessel or if the vessel was moving in the direction of the mammals, even if the mammals dove out of sight, or if the mammals were unable to move out of the path of the vessel), and if the vessel's course or speed could not be changed to avoid having the mammals enter the safety radius, the airgun array was powered down to one gun before the mammals were within the safety radius. Likewise, if a mammal was already within the safety zone when first detected, the airguns were powered down immediately. During the power-down procedure, one airgun continued firing, which would maintain a source Sound Pressure Level (SPL) of at least 180 dB re 1 μPa-m (rms) during the interruption of production seismic survey operations. *Shut-down* (see below) normally was implemented only if a marine mammal was detected within or about to enter the smaller safety zone around the

remaining operating airgun(s). Power-downs were achieved by calling the airgun operators by intercom or phone.

Full airgun activity did not resume (via a ramp up) until the marine mammal had cleared the safety zone. The mammal was considered to have cleared the safety zone if it had not been seen within the zone for **15 min** (small odontocetes, pinnipeds) or **30 min** (mysticetes and large odontocetes).

### *Shut-down Procedure*

If a cetacean or pinniped was detected within the applicable safety radius, the airgun(s) were shut down. Shut-down was accomplished by calling the airgun operators via the intercom or phone for a shut down.

After a shut down, the animal must have cleared the safety zone (see above for definitions) before start up procedures could begin. If the airgun(s) was/were shut down and no observer was on duty, then at least 30 min of observation was necessary prior to start up.

MMOs informed the bridge when start up of the airgun(s) could proceed. If a marine mammal was observed within the safety radii during the 30-min observation period, the observers were informed and the start up was be postponed. Start up commenced following a marine mammal sighting when the marine mammal was observed to exit the safety radii, or if no marine mammals were seen in the safety radii for **15 min** (small odontocetes, pinnipeds) or **30 min** (mysticetes and large odontocetes).

### *Ramp-up Procedure*

***Daytime Ramp-up Procedure***.—During daylight hours, a ramp up was required when the airgun array began operating after a specified duration of power down or shut down. Under normal operating conditions (vessel speed ~3.5 knots = ~6.5 km/h), a ramp up was required if the airguns were not in operation for **>11 min**. If the airguns had been shut down or powered down because of the presence of a marine mammal within or near the safety radius, ramp up could not begin until the safety radii were clear of marine mammals, as described below.

If at least one airgun had been operating, a ramp up could be initiated at any time provided two MMOs were on active watch during the ramp up. If a shut-down (no operating airguns) had lasted for **>11 min** and no MMOs had been on duty during that time, a 30-min observation period was required before ramp up could proceed. If the entire safety radius for the full array was not visible for the 30-min pre-ramp up observation period (because of fog or darkness, etc.), a ramp-up could not commence unless at least one airgun had been operational during the interruption of seismic survey operations with the full airgun array.

Ramp up of the airgun array began with one airgun. The number of airguns was then increased at a rate sufficient to produce an increase of ~6 dB per 5-min period when going from one airgun to the full array, which is the normal rate of ramp up for large airgun arrays. During the ramp up, the safety zone for the **full airgun array** was maintained even though fewer airguns were operating until the ramp-up was completed.

MMOs informed the bridge or the airgun operators in advance when ramp up could proceed. If a marine mammal was observed within its applicable safety radius during the 30-min observation period, or during the ramp up, the bridge and "observers" were informed, as usual, of any necessary mitigation measures (power down, shutdown). Following a marine mammal sighting, ramp up commenced when the marine mammal was observed to exit its safety radius, or if no marine mammals were seen in the safety radii for **15 min** (small odontocetes, pinnipeds) or **30 min** (mysticetes and large odontocetes).

***Nighttime Ramp-up Procedure***.—In addition to the requirements for daytime ramp-ups, during nighttime hours, ramp up could commence **only if the following conditions were met**:

a. The entire safety radius for the full-sized array was visible to MMOs using night-vision devices (unlikely with very large safety radii)

**or**

b. At least one airgun had been operating during the interruption of production seismic survey activities.

Under (b), if at least one airgun remained operational during the interruption of production seismic activities (e.g., there had been a power down to one airgun due to a marine mammal sighting beyond the safety radius for a single airgun), ramp up could proceed even if the outer part of the safety zone around the full-array was not visible.

## *Analyses*

This section describes the analyses of the marine mammal sightings and survey effort as documented during the cruise. It also describes the methods used to calculate densities and estimate the number of marine mammals potentially exposed to seismic sounds associated with the seismic survey. Sightings of marine mammals hauled out on the ice were included with sightings of marine mammals in the water for the density estimates. To calculate exposures, all the animals calculated in the density estimates were assumed to be in the water. Only marine mammals observed in the water were included in the direct estimates of animals exposed to seismic pulses. The analysis categories that were used were identified in Chapter 4. The primary analysis categories used to assess potential effects of seismic sounds on marine mammals were the "seismic" (airguns operating with shots at <3 min spacing) and "non-seismic" categories (periods before seismic started or >1 or >2 h after airguns were turned off, for pinnipeds and cetaceans, respectively). The analyses excluded the "post-seismic" period 3 min to 2 h after the airguns were turned off. The justification for the selection of these criteria is based on the size of the array in use and is provided below. These criteria were discussed in earlier cruise reports (see Haley and Koski 2004; Smultea et al. 2004, 2005; MacLean and Koski 2005; Holst et al. 2005a,b):

- The period up to 3 min after the last seismic shot is ~3× the normal shot interval. Mammal distribution and behavior during that short period are assumed to be similar to those while seismic surveying is ongoing.
- It is likely that any marine mammals near the vessel between 3 min and 30 min after the cessation of seismic activities would have been "recently exposed" (i.e., within the past 30 min) to sounds from the seismic survey. During at least a part of that period, the distribution and perhaps behavior of the marine mammals may still be influenced by the (previous) sounds.
- For some unknown part of the period from 30 min to 1 or 2 h post-seismic, it is possible that the distribution of the animals near the ship, and perhaps the behavior of some of those animals, would still be at least slightly affected by the (previous) seismic sounds.
- By 1 or 2 h after the cessation of seismic operations, the distribution and behavior of pinnipeds and cetaceans, respectively, would be expected to be indistinguishable from "normal" because of (a) waning of responses to past seismic activity, (b) re-distribution of mobile animals, and (c) movement of the ship and thus the MMOs. Given those considerations, plus the limited observed responses of most marine mammals to seismic surveys (e.g., Stone 2003; Smultea et al. 2004; Haley and Koski 2004; MacLean and Koski 2005; Holst et al. 2005a,b), it is unlikely that the distribution

or behavior of marine mammals near the vessel > 1 or 2 h post-seismic would be appreciably different from "normal" even if they had been exposed to seismic sounds earlier. Therefore, we consider animals seen >1 or 2 h after cessation of seismic operations to be unaffected by the (previous) seismic sounds.

As summarized in Chapter 4, marine mammal density was one of the parameters examined to assess differences in the distribution of marine mammals relative to the seismic vessel and chase vessel between seismic and non-seismic periods. Line-transect procedures for vessel-based surveys were followed. To allow for animals missed during daylight, we corrected our visual observations for missed cetaceans by using correction factors.

The formulas for calculating densities using this procedure were briefly described in Chapter 4 and are described in more detail below. As standard for line-transect estimation procedures, densities were corrected for the following two parameters before they were further analyzed:

- $g(0)$, a measure of detection bias. This factor allows for the fact that less than 100% of the animals present along a trackline are detected.
- $f(0)$, the reduced probability of detecting an animal with increasing distance from a trackline.

The $g(0)$ values used in the analysis were calculated for gray whales, bowhead whales, unidentified whales, bearded seals, ringed seals, Pacific walrus, unidentified seals, and unidentified pinnipeds. Where species specific values did not exist values for similar species were used. The $g(0)$ values for gray whales and bowhead whales were taken from previously calculated values for gray whales and right whales respectively. The $g(0)$ values for pinniped species observed during this study were taken from values calculated previously for pinniped species off California.. The $g(0)$ values used for this analysis were the same as those used by Koski et al. (1998), LGL (2005a), and LGL (2006). Other correction factors were extracted from species specific $g(0)$ tables produced for previous studies.

The $f(0)$ factors used in the analysis were calculated from observations made during this study. The sightings from all four vessels involved in this study were combined to keep the sample sizes adequately high and to minimize the number of $f(0)$s calculated. Only sightings that were during non-exposed seismic periods, that had useable effort, that had useable sightings and that were observed in seastates less than 6 were used. These sightings were imported into Distance 4.1 where the $f(0)$ values were calculated separately for each species. The default analysis method used was conventional distance sampling with a half-normal model and cosine expansion but with no stratification. As very few of the sightings were in large groups we simply used the ratio of f(0)s between group sizes of 1-16,17-60 and >60 in previous studies to estimate the appropriate f(0)s for the two larger group sizes in this study from the $f(0)$ calculated for the smallest group size in our sightings (1-16).

***Total number of Exposures (no per individual)***. — Estimates of the numbers of potential *exposures* of marine mammals to sound levels ≥160 dB re 1 $\mu Pa_{rms}$ were calculated by multiplying the total area of water ensonified to that degree by the density of marine mammals estimated by line transect methods. The density estimates include all marine mammals, in the water or on ice. The exposure estimates assume that the numbers of animals estimated from those densities are all in the water. The area of water ensonified was calculated using MapInfo Geographic Information System (GIS) software to create a "buffer" that extended on both sides of the vessel's trackline to the predicted 160-dB radius. Areas ensonified by the activities of the *Western Patriot* are shown in Table E2. The buffer included areas that were exposed to airgun sounds ≥160 dB one or more times (as a result of crossing tracklines or tracklines that were close enough for their 160 dB

Table E.2. The areas ($km^2$) potentially ensonified to various levels by the Patriot airgun array (16 airguns – 3900 $in^3$) and mitigation gun (1 airgun – 105 $in^3$), operating within the study area during seismic periods of the Chukchi Sea cruise, 17 Jul.−14 Oct. 2006. (A) Maximum area ensonified, with overlapping areas counted multiple times. (B) Total area ensonified, with overlapping areas counted only once.

| | Level of ensonification (dB re1µPa (rms)) | | | | |
|---|---|---|---|---|---|
| **Area ($km^2$)** | **160** | **170** | **180** | **190** | ***Total*** |
| **1 airgun (105 $in^3$)[a]** | | | | | |
| A. Including Overlap Area | 15,277.92 | 4,938.97 | 1,648.46 | 563.12 | ***22,428*** |
| B. Excluding Overlap Area | 4,987.64 | 2,373.88 | 1,170.22 | 497.20 | ***9,029*** |
| **16 airguns (3900 $in^3$)** | | | | | |
| A. Including Overlap Area | 321,127.22 | 128,452.83 | 41,658.81 | 12,648.95 | ***503,888*** |
| B. Excluding Overlap Area | 24,057.81 | 13,605.41 | 7,383.80 | 4,407.81 | ***49,455*** |

[a] Estimates for readii for this airgun volume were obtained from a similarly sized array used in other studies

zones to overlap). Areas of water ensonified on more than one occasion, due to overlapping tracklines, were repeatedly counted in the area calculation as many times as they were ensonified. "Corrected" densities of marine mammals were estimated as described in the above section.

Estimates of the numbers of potential *exposures* of marine mammals to sound levels ≥160 dB re 1 $\mu Pa_{rms}$ were calculated by multiplying the following three values:

- number of kilometers of seismic survey,
- width around trackline ensonified to ≥160 dB re 1 $\mu Pa_{rms}$ including *repeated counts* of areas ensonified on more than on occasion, and
- observed densities of marine mammals – "corrected" as summarized above

This value provides a maximum estimate of the number of exposures to sound levels ≥160 dB re 1 $\mu Pa_{rms}$ if marine mammals did not show avoidance reactions.

***Number of Individuals Exposed***.—The method described above likely overestimates the number of different individual marine mammals exposed to airgun sounds at received levels ≥160 dB. To provide an estimate of individuals exposed, the same calculation described above was performed, except that areas ensonified to ≥160 dB on more than one occasion, due to overlapping tracklines, were counted only once. In this project involving several tracklines, approximately 100 m apart, the amount of overlap was high.

Estimates of the potential number of *individual* marine mammals exposed to sound levels ≥160 dB re 1 $\mu Pa_{rms}$ were calculated by multiplying the following three values:

- number of kilometers of seismic survey,
- width around trackline ensonified to ≥160 dB re 1 $\mu Pa_{rms}$ including *only one count* of areas ensonified on more than on occasion, and
- observed densities of marine mammals – "corrected" as summarized above

The area of water considered ensonified in this calculation is therefore smaller than in the first calculation. During this cruise, the estimated number of individuals exposed is much less than the estimated number of exposure incidents because seismic lines were closely spaced and overlap of

ensonified areas occurred often. The calculated number of different individual marine mammals exposed to ≥160 dB re 1 $\mu Pa_{rms}$ is considered a minimum estimate because it does not account for the movement of marine mammals during the course of the study.

Average number of times that an animal was likely exposed to different sound levels was calculated by dividing the number of individual animals by the total number of exposures within a certain sound level.

# APPENDIX F:

## BACKGROUND ON MARINE MAMMALS IN THE CHUKCHI AND BEAUFORT SEAS

TABLE F-1. The habitat, abundance (in the Chukchi and Beaufort seas), and conservation status of marine mammals inhabiting the project area.

| Species | Habitat | Abundance | ESA[1] | IUCN[2] | CITES[3] |
|---|---|---|---|---|---|
| ***Odontocetes*** | | | | | |
| Beluga whale (Delphinapterus leucas) | Offshore, Coastal, Ice edges | 50,000[4] 39,257[5] | Not listed | VU | I |
| Narwhal (*Monodon monoceros*) | Offshore, Ice edge | Rare[6] | Not listed | DD | II |
| Killer whale (*Orcinus orca*) | Widely distributed | | Not listed | LR-cd | II |
| Harbor Porpoise (*Phocoena phocoena*) | Coastal, inland waters | Extralimital | Not listed | VU | II |
| ***Mysticetes*** | | | | | |
| Bowhead whale (*Balaena mysticetus*) | Pack ice & coastal | 10,545[7] | Endangered | LR-cd | I |
| Gray whale (*Eschrichtius robustus*) (eastern Pacific population) | Coastal, lagoons | 488[8] 17,500[9] | Not listed | LR-cd | I |
| Minke whale (*Balaenoptera acutorostrata*) | Shelf, coastal | 0 | Not listed | LR-cd | I |
| Fin whale (*Balaenoptera physalus*) | Slope, mostly pelagic | 0 | Endangered | EN | I |
| ***Pinnipeds*** | | | | | |
| Walrus (*Odobenus rosmarus*) | | 188,316[14] | Not listed | – | II |
| Bearded seal (*Erignathus barbatus*) | Pack ice | 300,000-450,000[15] 4863[16] | Not listed | – | – |
| Spotted seal (*Phoca largha*) | Pack ice | 1000[17] | Not listed | – | – |
| Ringed seal (*Pusa hispida*) | Landfast & pack ice | Up to 3.6 million[18] 245,048[19] 326,500[20] | Not listed | – | – |
| Ribbon seal (*Histriophoca fasciata*) | Ice | 100,000[21] | Not listed | N.A. | – |
| ***Carnivora*** | | | | | |
| Polar bear (*Ursus maritimus*) | Coastal, ice | >2500[22] 15,000[23] | Not listed | LR-cd | – |

[1] U.S. Endangered Species Act.

[2] IUCN Red List of Threatened Species (2003). Codes for IUCN classifications: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; LR = Lower Risk (-cd = Conservation Dependent; -nt = Near Threatened; -lc = Least Concern); DD = Data Deficient.

[3] Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2004).

[4] Total Western Alaska population, including Beaufort Sea animals that occur there during migration and in winter (Small and DeMaster 1995).

[5] Beaufort Sea population (IWC 2000).

[6] Population in Baffin Bay and the Canadian arctic archipelago is ~60,000 (DFO 2004); very few enter the Beaufort Sea.

[7] Abundance of bowheads surveyed near Barrow, as of 2001 (George et al. 2004); revised to 10,545 by Zeh and Punt (2005).

[8] Southern Chukchi Sea and northern Bering Sea (Clark and Moore 2002).

[9] North Pacific gray whale population (Rugh 2003 *in* Keller and Gerber 2004) ; see also Rugh et al. (2005).

[10] All feeding aggregations (Angliss and Lodge 2004).

[11] Abundance estimate for the central North Pacific stock (Calambokidis et al. 1997).

[12] Northern GOA and Aleutian Islands (Zerbini et al. 2004).

[13] North Pacific (Calambokidis and Barlow 2004).

[14] Pacific walrus population (USFWS 2000).
[15] Alaska population (USDI/MMS 1996).
[16] Eastern Chukchi Sea population (NMML, unpublished data).
[17] Alaska Beaufort Sea population (USDI/MMS 1996).
[18] Alaska estimate (Frost et al. 1988 *in* Angliss and Lodge 2004).
[19] Bering/Chukchi Sea population (Bengston et al. 2000).
[20] Alaskan Beaufort Sea population estimate (Amstrup 1995).

[21] Estimate for Bering Sea (Burns 1981b); current estimate is unavailable.

[22] Amstrup et al (2001).

[23] NWT Wildlife and Fisheries, http://www.nwtwildlife.rwed.gov.nt.ca/Publications/speciesatriskweb/polarbear.htm

* Listed as a strategic stock under the U.S. Marine Mammal Protection Act

# APPENDIX G:
## VISUAL EFFORT AND DETECTIONS

TABLE G.1. All visual observations from the *Patriot* (17 Jul.−14 Oct. 2006) and the chase vessel (14 Jul.−14 Oct. 2006), with regard to Beaufort sea state.

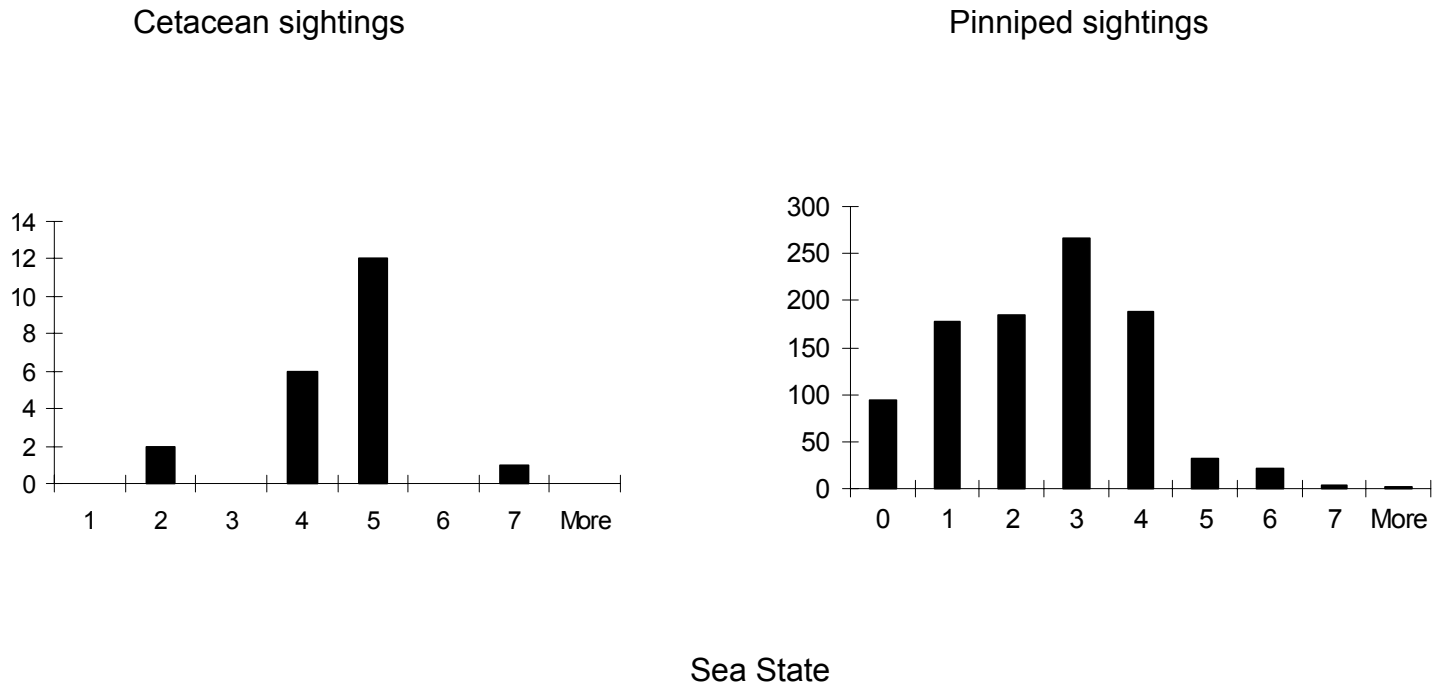


TABLE G.2 All and useable[a] visual observation effort from the *Patriot* (17 Jul.−14 Oct. 2006) and the chase vessel (14 Jul.−14 Oct. 2006), within the Chukchi Sea, in ***(A)*** hours, and ***(B)*** kilometers, subdivided by Beaufort Wind Force and airgun status. Ramp-up effort is included in the "Seismic" category.

| | All Effort | | | | | | | | | | | | | Useable[a] Effort | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Beaufort Wind Force*** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **not recorded** | ***Total*** | **0** | **1** | **2** | **3** | **4** | **5** | ***Total*** |
| ***Patriot*** | | | | | | | | | | | | | | | | | | | | |
| **A. Effort in h** | | | | | | | | | | | | | | | | | | | | |
| Non-seismic | 0 | 0 | 6 | 36 | 67 | 49 | 32 | 9 | 11 | 4 | 1 | 1 | ***216*** | 0 | 0 | 5 | 28 | 60 | 22 | ***115*** |
| Post seismic[b] | 0 | 0 | 1 | 1 | 2 | 4 | 1 | 0 | 0 | 1 | 0 | 0 | ***11*** | | | | | | | |
| Seismic | 0 | 5 | 102 | 340 | 493 | 424 | 209 | 121 | 26 | 4 | 0 | 13 | ***1738*** | 0 | 2 | 42 | 138 | 195 | 146 | ***523*** |
| ***Total*** | ***0*** | ***5*** | ***110*** | ***377*** | ***562*** | ***478*** | ***242*** | ***131*** | ***37*** | ***9*** | ***1*** | ***13*** | ***1965*** | ***0*** | ***2*** | ***47*** | ***166*** | ***255*** | ***168*** | ***638*** |
| **B. Effort in km** | | | | | | | | | | | | | | | | | | | | |
| Non-seismic | 0 | 0 | 46 | 276 | 512 | 426 | 250 | 77 | 92 | 49 | 11 | 5 | ***1744*** | 0 | 0 | 39 | 210 | 465 | 176 | ***890*** |
| Post seismic[b] | 0 | 0 | 12 | 10 | 16 | 36 | 7 | 0 | 0 | 9 | 0 | 0 | ***90*** | | | | | | | |
| Seismic | 0 | 43 | 941 | 3147 | 4555 | 3921 | 1930 | 1108 | 233 | 35 | 0 | 115 | ***16028*** | 0 | 16 | 388 | 1273 | 1788 | 1336 | ***4801*** |
| ***Total*** | ***0*** | ***43*** | ***1000*** | ***3433*** | ***5083*** | ***4383*** | ***2187*** | ***1185*** | ***325*** | ***92*** | ***11*** | ***120*** | ***17862*** | ***0*** | ***16*** | ***427*** | ***1483*** | ***2253*** | ***1512*** | ***5691*** |
| ***Chase Vessel*** | | | | | | | | | | | | | | | | | | | | |
| **A. Effort in h** | | | | | | | | | | | | | | | | | | | | |
| Non-seismic | 23 | 78 | 171 | 272 | 322 | 134 | 63 | 48 | 0 | 0 | 0 | 0 | **1111** | 15 | 53 | 99 | 138 | 157 | 78 | 540 |
| **B. Effort in km** | | | | | | | | | | | | | | | | | | | | |
| Non-seismic | 302 | 933 | 1961 | 3264 | 3328 | 1527 | 726 | 501 | 0 | 0 | 2 | 0 | **12544** | 213 | 641 | 1172 | 1884 | 1706 | 865 | 6481 |
| ***Total Effort in h*** | ***23*** | ***83*** | ***281*** | ***649*** | ***884*** | ***612*** | ***305*** | ***179*** | ***37*** | ***9*** | ***1*** | ***13*** | ***3076*** | ***15*** | ***55*** | ***146*** | ***304*** | ***412*** | ***246*** | ***1178*** |
| ***Total Effort in km*** | ***302*** | ***976*** | ***2961*** | ***6697*** | ***8411*** | ***5910*** | ***2913*** | ***1686*** | ***325*** | ***92*** | ***13*** | ***120*** | ***30406*** | ***213*** | ***657*** | ***1599*** | ***3367*** | ***3959*** | ***2377*** | ***12172*** |

[a] Useable sightings are those made during useable daylight periods of visual observation, as defined in *Acronyms and Abbreviations*.

[b] Period encompassing 3 min. to 2 hrs. after all airguns are shut down.

TABLE G.3. Total number of groups (individuals in parentheses) of marine mammals observed from the *Patriot* (17 Jul.−14 Oct. 2006) and chase vessel (14 Jul.−14 Oct. 2006) by species, seismic activity, and transit periods during the Chukchi Sea cruise. See Table 5.1 for the total number of useable[a] sightings (a subtotal of the numbers shown here).

| | **Periods within Chukchi Sea Study Area** | | | **Transit Periods within Bering Sea** | ***Total*** | |
|---|---|---|---|---|---|---|
| **Species** | **Non-Seismic[b]** | **Post-Seismic[c]** | **Seismic** | ***July*** [d,e] | **Sightings** | **Indiv.** |
| **Cetaceans** | | | | | | |
| Beluga Whale | 0 | 0 | 2(2) | 0 | 2 | 2 |
| Dall's Porpoise | 0 | 0 | 0 | 2(3) | 2 | 3 |
| Harbor Porpoise | 0 | 0 | 0 | 1(1) | 1 | 1 |
| Bowhead Whale | 1(1) | 0 | 3(3) | 0 | 4 | 4 |
| Gray Whale | 2(4) | 0 | 2(3) | 6(11) | 10 | 18 |
| Minke Whale | 0 | 0 | 0 | 1(1) | 1 | 1 |
| Unidentified Mysticete Whale | 7(7) | 0 | 0 | 0 | 7 | 7 |
| Unidentified Whale | 1(1) | 0 | 4(4) | 5(6) | 10 | 11 |
| Unidentified Dolphin | 0 | 0 | 0 | 0 | 0 | 0 |
| **Pinnipeds** | | | | | | |
| Pacific Walrus | 2(2) | 0 | 0 | 2(2) | 25 | 34 |
| Bearded Seal | 0 | 0 | 0 | 0 | 10 | 13 |
| Ringed Seal | 0 | 0 | 0 | 0 | 17 | 17 |
| Spotted Seal | 0 | 0 | 0 | 5(5) | 14 | 15 |
| Unidentified Seal | 2(2) | 1(1) | 0 | 0 | 77 | 80 |
| Unidentified Pinniped | 0 | 0 | 0 | 0 | 6 | 6 |
| **Unknown** | | | | | | |
| Unknown | 0 | 0 | 4(4) | 0 | 4 | 4 |
| ***Total*** | ***15(17)*** | ***1(1)*** | ***15(16)*** | ***22(29)*** | ***190*** | ***216*** |

[a] Useable sightings are those made during useable daylight periods of visual observation, as defined in *Acronyms and*

[b] Includes both *Patriot* and chase vessel sightings.

[c] From 3 min to 1 hr after a seismic period for pinnipeds, or 3 min to 2 hrs after a seismic period for cetaceans.

[d] Includes transit periods when *Patriot* and chase vessel travelled from Dutch Harbor, AK, to the Chukchi Sea study area

[e] No sightings were recorded during the September - October transit of the *Patriot.* Marine mammal observers were not aboard the chase vessel during transit in October.

Table G.4. Visual sightings of marine mammals made from the Patriot (17 Jul.−14 Oct. 2006) and the Chase Vessel (14 Jul.−14 Oct. 2006) within the Chukchi Sea survey area and during transits.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Patriot | 1 | Unidentified mysticete whale | N | 1 | 18-Jul | 2:27 | B | 800 | 984 | UN | SW | 5 | 1 | OT | 0 | none |
| Patriot | 2 | Unidentified mysticete whale | N | 1 | 18-Jul | 2:57 | B | 500 | 583 | SP | BL | 5 | 1 | OT | 0 | none |
| Patriot | 3 | Unidentified mysticete whale | Y | 1 | 18-Jul | 2:57 | B | 2000 | 800 | UN | BL | 5 | 1 | OT | 0 | none |
| Patriot | 4 | Gray whale | Y | 1 | 18-Jul | 3:01 | B | 800 | 854 | SP | SW | 5 | 1 | OT | 0 | none |
| Patriot | 5 | Unidentified mysticete whale | Y | 1 | 18-Jul | 3:03 | B | 2000 | 2165 | UN | BL | 5 | 1 | OT | 0 | none |
| Patriot | 6 | Gray whale | Y | 3 | 18-Jul | 3:05 | B | 2500 | 2662 | SP | SW | 5 | 1 | OT | 0 | none |
| Patriot | 7 | Unidentified mysticete whale | Y | 1 | 18-Jul | 3:10 | B | 800 | 984 | UN | BL | 5 | 1 | OT | 0 | none |
| Patriot | 8 | Unidentified mysticete whale | Y | 1 | 18-Jul | 3:12 | B | 2500 | 2662 | UN | BL | 5 | 1 | OT | 0 | none |
| Patriot | 9 | Pacific walrus | Y | 1 | 19-Jul | 4:05 | B | 150 | 396 | SA | SW | 4 | 1 | OT | 0 | none |
| Patriot | 10 | Unidentified mysticete whale | Y | 1 | 19-Jul | 17:21 | B | 1400 | 1400 | UN | SW | 4 | 1 | OT | 0 | none |
| Patriot | 11 | Unidentified seal | Y | 1 | 22-Jul | 9:46 | B | 150 | 335 | SA | UN | 4 | 1 | OT | 0 | none |
| Patriot | 12 | Bowhead whale | Y | 1 | 23-Jul | 20:24 | B | 888 | 1070 | SP | BL | 5 | 1 | OT | 0 | none |
| Patriot | 13 | Bowhead whale | Y | 1 | 24-Jul | 21:43 | B | 756 | 824 | UN | BL | 5 | 1 | SH | 3390 | PZ |
| Patriot | 14 | Bowhead whale | Y | 1 | 24-Jul | 21:58 | B | 1074 | 813 | SP | BL | 5 | 1 | SH | 105 | none |
| Patriot | 15 | Pacific walrus | Y | 1 | 25-Jul | 10:27 | B | 306 | 545 | SP | LO | 3 | 1 | RU | 99 | none |
| Patriot | 16 | Spotted seal | N | 1 | 25-Jul | 17:17 | B | 350 | 650 | PE | SW | 3 | 1 | SH | 105 | none |
| Patriot | 17 | Spotted seal | N | 1 | 25-Jul | 18:01 | B | 306 | 524 | UN | SW | 3 | 1 | RU | 99 | none |
| Patriot | 18 | Spotted seal | N | 1 | 25-Jul | 18:50 | B | 584 | 656 | PE | SW | 3 | 1 | LS | 3390 | none |
| Patriot | 19 | Unidentified seal | N | 1 | 25-Jul | 20:02 | B | 347 | 560 | SA | SW | 3 | 1 | LS | 3390 | none |
| Patriot | 20 | Unidentified seal | N | 1 | 25-Jul | 22:37 | B | 207 | 441 | SP | LO | 3 | 1 | OT | 0 | none |
| Patriot | 21 | Unidentified seal | N | 1 | 26-Jul | 2:22 | B | 10 | 300 | NO | FD | 99 | 1 | OT | 0 | none |
| Patriot | 22 | Unidentified seal | N | 1 | 26-Jul | 3:18 | B | 90 | 374 | SA | LO | 2 | 1 | SH | 105 | none |
| Patriot | 23 | Unidentified seal | N | 1 | 26-Jul | 3:54 | B | 1000 | 1268 | PE | LO | 3 | 1 | SH | 105 | none |
| Patriot | 24 | Spotted seal | Y | 2 | 26-Jul | 4:02 | B | 70 | 370 | PE | LO | 3 | 1 | SH | 105 | none |
| Patriot | 25 | Spotted seal | Y | 1 | 26-Jul | 4:20 | B | 600 | 303 | SA | LO | 2 | 1 | SH | 105 | none |
| Patriot | 26 | Spotted seal | Y | 1 | 26-Jul | 4:27 | B | 325 | 538 | PE | LO | 2 | 1 | SH | 105 | none |
| Patriot | 27 | Spotted seal | Y | 1 | 26-Jul | 4:42 | B | 40 | 321 | SA | LO | 2 | 1 | SH | 105 | none |
| Patriot | 28 | Unidentified seal | Y | 1 | 26-Jul | 4:48 | B | 306 | 428 | SA | ST | 2 | 1 | SH | 105 | none |
| Patriot | 29 | Unidentified seal | N | 1 | 26-Jul | 5:33 | B | 300 | 519 | UN | LO | 2 | 1 | SH | 105 | none |
| Patriot | 30 | Unidentified seal | Y | 1 | 26-Jul | 6:00 | B | 272 | 30 | SA | SW | 2 | 1 | SZ | 0 | SZ |
| Patriot | 31 | Unidentified seal | Y | 1 | 26-Jul | 7:49 | B | 1362 | 1534 | PE | SW | 3 | 1 | LS | 3390 | none |
| Patriot | 32 | Unidentified seal | Y | 1 | 26-Jul | 8:12 | B | 325 | 541 | SP | LO | 2 | 1 | LS | 3390 | none |
| Patriot | 33 | Unidentified seal | Y | 1 | 26-Jul | 15:16 | B | 659 | 992 | SA | SW | 2 | 1 | LS | 3390 | none |
| Patriot | 34 | Spotted seal | Y | 1 | 26-Jul | 15:49 | B | 300 | 519 | SA | ST | 2 | 1 | LS | 3390 | none |
| Patriot | 35 | Spotted seal | Y | 1 | 26-Jul | 16:01 | B | 306 | 428 | SA | ST | 2 | 1 | LS | 3390 | none |
| Patriot | 36 | Ringed seal | Y | 1 | 26-Jul | 16:16 | B | 6 | 303 | SA | SW | 3 | 1 | PZ | 105 | PZ |
| Patriot | 37 | Bearded seal | Y | 1 | 26-Jul | 17:21 | B | 45 | 300 | SA | TH | 3 | 1 | SH | 105 | none |
| Patriot | 38 | Bearded seal | Y | 4 | 29-Jul | 14:00 | B | 584 | 778 | NO | LO | 4 | 1 | LS | 3390 | none |
| Patriot | 39 | Ringed seal | Y | 1 | 29-Jul | 14:00 | B | 150 | 150 | SA | TH | 4 | 1 | PZ | 105 | PZ |
| Patriot | 40 | Pacific walrus | N | 2 | 29-Jul | 17:07 | B | 756 | 930 | SP | SW | 3 | 1 | LS | 3390 | none |
| Patriot | 41 | Unidentified seal | Y | 1 | 29-Jul | 18:03 | B | 150 | 396 | MI | LO | 3 | 1 | PZ | 105 | PZ |
| Patriot | 42 | Ringed seal | Y | 1 | 30-Jul | 3:12 | B | 40 | 321 | SA | LO | 4 | 1 | PZ | 105 | PZ |
| Patriot | 43 | Bearded seal | Y | 1 | 1-Aug | 16:22 | B | 84 | 349 | SA | LO | 3 | 1 | PZ | 105 | PZ |
| Patriot | 44 | Unidentified seal | N | 1 | 3-Aug | 0:49 | B | 25 | 313 | UN | TH | 3 | 1 | LS | 3390 | PZ |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Patriot | 45 | Unidentified seal | N | 1 | 3-Aug | 1:14 | B | 50 | 350 | NO | LO | 3 | 1 | PZ | 105 | PZ |
| Patriot | 46 | Ringed seal | N | 1 | 3-Aug | 1:48 | B | 50 | 327 | SP | SW | 3 | 1 | PZ | 105 | PZ |
| Patriot | 47 | Unidentified seal | N | 1 | 3-Aug | 8:58 | B | 100 | 344 | SA | TH | 3 | 1 | PZ | 105 | PZ |
| Patriot | 48 | Unidentified seal | N | 1 | 3-Aug | 12:40 | B | 100 | 360 | SA | SW | 3 | 1 | PZ | 105 | PZ |
| Patriot | 49 | Bearded seal | N | 1 | 3-Aug | 13:05 | B | 350 | 650 | ST | SW | 3 | 1 | SH | 105 | none |
| Patriot | 50 | Pacific walrus | Y | 1 | 3-Aug | 21:49 | B | 200 | 304 | MI | LO | 4 | 1 | PZ | 105 | PZ |
| Patriot | 51 | Unidentified pinniped | Y | 1 | 4-Aug | 7:02 | B | 40 | 321 | UN | TH | 4 | 1 | PZ | 105 | PZ |
| Patriot | 52 | Pacific walrus | N | 2 | 5-Aug | 9:19 | B | 14 | 300 | SA | TH | 4 | 1 | PZ | 105 | PZ |
| Patriot | 53 | Unidentified seal | Y | 1 | 6-Aug | 0:46 | B | 60 | 334 | UN | LO | 2 | 1 | PZ | 105 | PZ |
| Patriot | 54 | Bearded seal | Y | 1 | 6-Aug | 1:29 | B | 200 | 313 | SP | SW | 2 | 1 | SH | 105 | none |
| Patriot | 55 | Ringed seal | Y | 1 | 6-Aug | 14:15 | C | 125 | 378 | SA | SW | 2 | 1 | SH | 105 | none |
| Patriot | 56 | Ringed seal | Y | 1 | 6-Aug | 14:38 | C | 240 | 468 | SP | SW | 3 | 1 | SH | 105 | none |
| Patriot | 57 | Unidentified seal | N | 1 | 6-Aug | 15:05 | C | 290 | 569 | SA | TH | 2 | 1 | LS | 3390 | none |
| Patriot | 58 | Unidentified seal | N | 1 | 6-Aug | 15:14 | B | 360 | 572 | SA | TH | 2 | 1 | LS | 3390 | none |
| Patriot | 59 | Bearded seal | Y | 1 | 11-Aug | 1:06 | C | 50 | 327 | SA | SW | 5 | 1 | SH | 105 | none |
| Patriot | 60 | Pacific walrus | Y | 2 | 12-Aug | 22:45 | C | 306 | 524 | SA | LO | 5 | 1 | SH | 105 | none |
| Patriot | 61 | Bearded seal | Y | 1 | 16-Aug | 16:00 | B | 756 | 942 | NO | LO | 3 | 1 | SH | 105 | none |
| Patriot | 62 | Ringed seal | Y | 1 | 16-Aug | 20:20 | B | 200 | 150 | MI | SW | 3 | 1 | LS | 3390 | PZ |
| Patriot | 63 | Ringed seal | Y | 1 | 16-Aug | 20:30 | B | 207 | 441 | MI | SW | 3 | 1 | SH | 105 | none |
| Patriot | 64 | Unidentified seal | Y | 2 | 16-Aug | 20:47 | B | 347 | 560 | SA | PO | 3 | 1 | SH | 105 | none |
| Patriot | 65 | Unidentified seal | Y | 1 | 16-Aug | 20:47 | B | 1 | 300 | UN | LO | 3 | 1 | SH | 105 | none |
| Patriot | 66 | Unidentified seal | Y | 1 | 16-Aug | 22:43 | B | 476 | 677 | SP | SW | 2 | 1 | LS | 3390 | none |
| Patriot | 67 | Ringed seal | Y | 1 | 17-Aug | 0:07 | B | 200 | 435 | SA | SW | 2 | 1 | LS | 3390 | none |
| Patriot | 68 | Unidentified seal | Y | 1 | 17-Aug | 3:41 | B | 20 | 310 | SA | SW | 2 | 1 | PZ | 105 | PZ |
| Patriot | 69 | Unidentified seal | Y | 1 | 17-Aug | 4:12 | B | 192 | 476 | SA | FD | 2 | 1 | RU | 99 | none |
| Patriot | 70 | Unidentified seal | Y | 1 | 17-Aug | 4:30 | B | 206 | 489 | SA | SW | 2 | 1 | LS | 3390 | none |
| Patriot | 71 | Unidentified seal | Y | 1 | 17-Aug | 4:47 | B | 350 | 563 | SA | TH | 2 | 1 | LS | 3390 | none |
| Patriot | 72 | Pacific walrus | Y | 3 | 17-Aug | 4:58 | B | 200 | 344 | SA | SW | 2 | 1 | PZ | 105 | PZ |
| Patriot | 73 | Pacific walrus | Y | 1 | 21-Aug | 0:14 | B | 350 | 627 | UN | UN | 4 | 1 | OT | 0 | none |
| Patriot | 74 | Unidentified pinniped | N | 1 | 23-Aug | 21:09 | B | 584 | 1153 | UN | SW | 4 | 1 | SH | 105 | none |
| Patriot | 75 | Beluga whale | N | 1 | 24-Aug | 15:33 | B | 400 | 500 | DE | | 5 | 1 | LS | 3390 | none |
| Patriot | 76 | Gray whale | N | 1 | 25-Aug | 19:04 | B | 600 | 872 | DE | | 4 | 1 | RU | 99 | none |
| Patriot | 77 | Pacific walrus | N | 1 | 26-Aug | 2:18 | B | 192 | 356 | SA | SW | 4 | 1 | LS | 3390 | none |
| Patriot | 78 | Unidentified whale | N | 1 | 26-Aug | 4:41 | B | 192 | 429 | DE | OT | 4 | 1 | SH | 105 | none |
| Patriot | 79 | Ringed seal | N | 1 | 28-Aug | 15:50 | B | 347 | 625 | SA | BR | 2 | 1 | LS | 3390 | none |
| Patriot | 80 | Ringed seal | N | 1 | 28-Aug | 16:51 | B | 325 | 541 | SA | LO | 3 | 1 | LS | 3390 | none |
| Patriot | 81 | Bearded seal | N | 1 | 29-Aug | 2:34 | B | 306 | 524 | SA | LO | 2 | 1 | LS | 3390 | none |
| Patriot | 82 | Gray whale | N | 2 | 29-Aug | 2:57 | B | 2500 | 360 | PE | BR | 2 | 1 | LS | 3390 | PZ |
| Patriot | 84 | Unidentified seal | N | 1 | 29-Aug | 3:10 | B | 50 | 344 | NO | LO | 4 | 1 | SH | 105 | none |
| Patriot | 85 | Pacific walrus | N | 1 | 30-Aug | 4:21 | B | 207 | 381 | SA | LO | 3 | 1 | PZ | 105 | PZ |
| Patriot | 86 | Ringed seal | N | 1 | 30-Aug | 15:42 | B | 178 | 462 | MI | LO | 2 | 1 | LS | 3390 | none |
| Patriot | 87 | Pacific walrus | Y | 2 | 30-Aug | 16:30 | B | 150 | 309 | SA | LO | 3 | 1 | PZ | 105 | PZ |
| Patriot | 88 | Unidentified seal | Y | 1 | 30-Aug | 16:52 | B | 200 | 483 | SA | DI | 3 | 1 | SH | 105 | none |
| Patriot | 89 | Bearded seal | N | 1 | 30-Aug | 20:46 | B | 192 | 389 | NO | LO | 5 | 1 | PZ | 105 | PZ |
| Patriot | 90 | Unidentified seal | N | 1 | 30-Aug | 22:58 | B | 400 | 519 | UN | SW | 99 | 1 | LS | 3390 | none |
| Patriot | 91 | Unidentified seal | N | 1 | 31-Aug | 0:16 | B | 247 | 528 | SA | LO | 3 | 1 | SH | 105 | none |
| Patriot | 92 | Ringed seal | N | 1 | 31-Aug | 0:20 | B | 476 | 677 | SA | SW | 3 | 1 | SH | 105 | none |
| Patriot | 93 | Unidentified seal | N | 1 | 31-Aug | 0:21 | B | 401 | 677 | SA | SW | 3 | 1 | SH | 105 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. (in$^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Patriot | 94 | Unidentified seal | N | 1 | 31-Aug | 0:23 | B | 401 | 677 | UN | SW | 3 | 1 | SH | 105 | none |
| Patriot | 95 | Unidentified seal | N | 1 | 31-Aug | 0:25 | B | 476 | 677 | SA | SW | 3 | 1 | SH | 105 | none |
| Patriot | 96 | Unidentified seal | N | 1 | 31-Aug | 0:29 | B | 401 | 609 | SA | LG | 3 | 1 | RU | 99 | none |
| Patriot | 97 | Unidentified seal | N | 1 | 31-Aug | 0:33 | B | 178 | 360 | NO | SW | 3 | 1 | PZ | 105 | PZ |
| Patriot | 98 | Unidentified seal | N | 1 | 31-Aug | 0:41 | B | 150 | 396 | SA | SW | 3 | 1 | SH | 105 | none |
| Patriot | 99 | Unidentified seal | N | 1 | 31-Aug | 1:23 | B | 225 | 396 | UN | SW | 2 | 1 | PZ | 105 | PZ |
| Patriot | 100 | Pacific walrus | N | 1 | 31-Aug | 2:16 | B | 247 | 474 | SA | SW | 2 | 1 | LS | 3390 | none |
| Patriot | 101 | Unidentified seal | Y | 1 | 31-Aug | 2:41 | B | 1074 | 547 | NO | SW | 2 | 1 | LS | 3390 | none |
| Patriot | 102 | Unidentified seal | Y | 1 | 31-Aug | 5:23 | B | 100 | 327 | ST | LO | 3 | 1 | PD | 105 | none |
| Patriot | 103 | Unidentified seal | Y | 1 | 31-Aug | 6:10 | B | 225 | 456 | SA | SW | 3 | 1 | RU | 99 | none |
| Patriot | 104 | Unidentified seal | N | 2 | 31-Aug | 7:25 | B | 225 | 507 | SA | SA | 3 | 1 | LS | 3390 | none |
| Patriot | 105 | Unidentified seal | N | 1 | 31-Aug | 7:42 | B | 150 | 450 | SA | SW | 3 | 1 | PZ | 105 | PZ |
| Patriot | 106 | Unidentified seal | N | 2 | 31-Aug | 22:40 | B | 60 | 308 | SA | SW | 6 | 1 | PZ | 105 | PZ |
| Patriot | 107 | Pacific walrus | N | 2 | 1-Sep | 19:19 | B | 178 | 418 | SP | LO | 4 | 1 | PZ | 105 | PZ |
| Patriot | 108 | Unidentified seal | N | 1 | 2-Sep | 2:44 | B | 40 | 340 | SA | FD | 4 | 1 | PZ | 105 | PZ |
| Patriot | 109 | Ringed seal | N | 1 | 2-Sep | 4:45 | B | 50 | 327 | MI | TH | 3 | 1 | PZ | 105 | PZ |
| Patriot | 110 | Unidentified seal | N | 1 | 4-Sep | 22:31 | B | 50 | 350 | PE | SW | 7 | 1 | PZ | 105 | PZ |
| Patriot | 111 | Ringed seal | N | 1 | 10-Sep | 4:58 | B | 25 | 321 | PE | LO | 3 | 1 | PZ | 105 | PZ |
| Patriot | 112 | Unidentified seal | N | 1 | 10-Sep | 6:01 | B | 50 | 344 | SA | LO | 5 | 1 | PD | 105 | none |
| Patriot | 113 | Unidentified whale | N | 1 | 12-Sep | 19:25 | B | 1074 | 1115 | UN | BL | 7 | 1 | SH | 105 | none |
| Patriot | 114 | Ringed seal | N | 1 | 15-Sep | 20:54 | B | 178 | 436 | SA | LO | 4 | 1 | SH | 105 | none |
| Patriot | 115 | Unidentified seal | Y | 1 | 15-Sep | 23:28 | B | 150 | 396 | SA | LO | 4 | 1 | PZ | 105 | PZ |
| Patriot | 116 | Unidentified seal | Y | 1 | 16-Sep | 0:00 | B | 150 | 436 | SA | LO | 4 | 1 | SH | 105 | none |
| Patriot | 117 | Unidentified seal | Y | 1 | 16-Sep | 1:49 | B | 273 | 553 | SA | LO | 4 | 1 | LS | 3390 | none |
| Patriot | 118 | Pacific walrus | N | 1 | 21-Sep | 0:49 | B | 400 | 389 | NO | LO | 4 | 1 | SH | 105 | none |
| Patriot | 119 | Pacific walrus | Y | 2 | 22-Sep | 3:59 | B | 200 | 435 | ST | SW | 4 | 1 | PZ | 105 | PZ |
| Patriot | 120 | Unidentified seal | Y | 1 | 23-Sep | 16:36 | B | 40 | 321 | SA | SW | 2 | 1 | PZ | 105 | PZ |
| Patriot | 121 | Pacific walrus | Y | 1 | 23-Sep | 16:45 | B | 500 | 500 | UN | UN | 2 | 1 | RU | 99 | none |
| Patriot | 122 | Unidentified seal | Y | 1 | 23-Sep | 17:01 | B | 250 | 476 | SA | SW | 2 | 1 | LS | 3390 | none |
| Patriot | 123 | Unidentified seal | Y | 1 | 24-Sep | 2:59 | B | 50 | 344 | PE | SW | 2 | 1 | SH | 105 | none |
| Patriot | 124 | Unidentified seal | Y | 1 | 24-Sep | 17:31 | B | 306 | 326 | ST | SW | 3 | 1 | PZ | 105 | PZ |
| Patriot | 125 | Unidentified seal | Y | 1 | 24-Sep | 18:05 | C | 100 | 316 | SA | UN | 4 | 1 | SH | 105 | none |
| Patriot | 126 | Unidentified seal | Y | 1 | 24-Sep | 18:11 | C | 584 | 857 | ST | SW | 3 | 1 | RU | 99 | none |
| Patriot | 127 | Unidentified seal | Y | 1 | 24-Sep | 18:31 | C | 50 | 350 | SA | SW | 3 | 1 | PZ | 105 | PZ |
| Patriot | 128 | Unidentified pinniped | Y | 1 | 24-Sep | 20:23 | B | 1362 | 1300 | NO | SW | 3 | 1 | LS | 3390 | none |
| Patriot | 129 | Unidentified seal | Y | 1 | 24-Sep | 20:39 | B | 524 | 722 | NO | SW | 3 | 1 | LS | 3390 | none |
| Patriot | 130 | Unidentified pinniped | Y | 1 | 24-Sep | 21:11 | B | 1074 | 1115 | NO | SW | 3 | 1 | LS | 3390 | none |
| Patriot | 131 | Bearded seal | Y | 1 | 24-Sep | 21:15 | B | 524 | 603 | SA | LO | 3 | 1 | LS | 3390 | none |
| Patriot | 132 | Unidentified pinniped | Y | 1 | 24-Sep | 21:22 | B | 584 | 722 | MI | SW | 3 | 1 | LS | 3390 | none |
| Patriot | 133 | Unidentified seal | Y | 1 | 24-Sep | 22:10 | B | 50 | 327 | NO | TH | 4 | 1 | SH | 105 | none |
| Patriot | 134 | Unidentified seal | Y | 1 | 24-Sep | 23:31 | B | 584 | 656 | SA | SW | 1 | 1 | RU | 99 | none |
| Patriot | 135 | Unidentified seal | Y | 1 | 25-Sep | 1:32 | B | 584 | 884 | SA | FD | 3 | 1 | PZ | 105 | PZ |
| Patriot | 136 | Pacific walrus | Y | 1 | 25-Sep | 2:14 | B | 273 | 519 | ST | SW | 2 | 1 | PZ | 105 | PZ |
| Patriot | 137 | Pacific walrus | Y | 1 | 25-Sep | 3:25 | B | 347 | 483 | NO | LG | 2 | 1 | LS | 3390 | none |
| Patriot | 138 | Pacific walrus | N | 1 | 26-Sep | 21:33 | B | 306 | 483 | NO | LO | 6 | 1 | SH | 105 | none |
| Patriot | 139 | Pacific walrus | N | 1 | 28-Sep | 17:44 | B | 80 | 308 | SP | SW | 6 | 1 | PZ | 105 | PZ |
| Patriot | 140 | Unidentified seal | N | 1 | 29-Sep | 17:15 | B | 30 | 30 | SA | SW | 2 | 1 | PZ | 105 | PZ |
| Patriot | 141 | Unidentified seal | Y | 1 | 29-Sep | 17:55 | B | 20 | 320 | SA | SW | 3 | 1 | PZ | 105 | PZ |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. (in$^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Patriot | 142 | Unidentified seal | Y | 1 | 29-Sep | 18:20 | B | 15 | 307 | SA | SW | 3 | 1 | PZ | 105 | PZ |
| Patriot | 143 | Unidentified seal | Y | 1 | 29-Sep | 18:33 | B | 401 | 609 | UN | UN | 3 | 1 | LS | 3390 | none |
| Patriot | 144 | Pacific walrus | Y | 1 | 29-Sep | 18:39 | B | 1074 | 1115 | SP | SW | 3 | 1 | LS | 3390 | none |
| Patriot | 145 | Unidentified seal | Y | 1 | 29-Sep | 18:41 | B | 347 | 647 | SA | UN | 3 | 1 | PZ | 105 | PZ |
| Patriot | 146 | Unidentified seal | Y | 1 | 29-Sep | 19:10 | B | 476 | 750 | SA | LO | 4 | 1 | LS | 3390 | none |
| Patriot | 147 | Unidentified seal | Y | 1 | 29-Sep | 19:29 | B | 273 | 553 | SA | SW | 3 | 1 | LS | 3390 | none |
| Patriot | 148 | Unidentified seal | Y | 1 | 29-Sep | 20:13 | B | 247 | 389 | SA | SW | 3 | 1 | SH | 105 | none |
| Patriot | 149 | Unidentified seal | Y | 1 | 29-Sep | 20:29 | B | 306 | 606 | SA | SW | 3 | 1 | SH | 105 | none |
| Patriot | 150 | Unidentified seal | Y | 1 | 29-Sep | 21:23 | B | 100 | 406 | SA | SW | 3 | 1 | SH | 105 | none |
| Patriot | 151 | Unidentified seal | Y | 1 | 29-Sep | 21:35 | B | 524 | 798 | SA | SW | 3 | 1 | RU | 99 | none |
| Patriot | 152 | Unidentified seal | Y | 1 | 29-Sep | 22:21 | B | 306 | 579 | SA | SW | 3 | 1 | LS | 3390 | none |
| Patriot | 153 | Pacific walrus | Y | 1 | 29-Sep | 22:31 | B | 300 | 490 | SP | SW | 3 | 1 | LS | 3390 | none |
| Patriot | 154 | Unidentified seal | N | 1 | 29-Sep | 23:52 | B | 401 | 500 | SA | SW | 4 | 1 | SH | 105 | none |
| Patriot | 155 | Unidentified seal | Y | 1 | 30-Sep | 0:38 | B | 207 | 483 | UN | UN | 3 | 1 | SH | 105 | none |
| Patriot | 156 | Pacific walrus | N | 2 | 5-Oct | 3:17 | B | 476 | 750 | SA | SW | 6 | 1 | LS | 3390 | none |
| Patriot | 157 | Unidentified seal | N | 1 | 11-Oct | 21:03 | B | 150 | 389 | NO | MI | 6 | 1 | SH | 105 | none |
| Patriot | 158 | Ringed seal | N | 1 | 12-Oct | 0:23 | B | 80 | 335 | SA | SW | 6 | 1 | SH | 105 | none |
| Patriot | 161 | Unidentified whale | N | 1 | 22-Jul | 3:53 | B | 2500 | 2662 | DE |  | 4 | 1 | OT | 0 | none |
| Patriot | 162 | Bowhead whale | N | 1 | 25-Jul | 7:37 | B | 300 | 424 | DE |  | 2 | 1 | SH | 105 | none |
| Patriot | 163 | Unknown | Y | 1 | 26-Jul | 8:23 | B | 1074 | 1251 | UN | UN | 2 | 1 | LS | 3390 | none |
| Patriot | 164 | Beluga whale | N | 1 | 27-Jul | 11:14 | B | 659 | 849 | DE |  | 5 | 1 | SH | 105 | none |
| Patriot | 165 | Unknown | N | 1 | 28-Jul | 20:37 | B | 584 | 656 | DE |  | 3 | 1 | LS | 3390 | none |
| Patriot | 166 | Unidentified whale | N | 1 | 29-Jul | 13:53 | B | 584 | 857 | DE |  | 4 | 1 | LS | 3390 | none |
| Patriot | 167 | Unidentified seal | N | 1 | 1-Aug | 19:51 | B | 1400 | 1400 | DE |  | 3 | 1 | SH | 105 | none |
| Patriot | 168 | Unknown | N | 1 | 13-Aug | 5:18 | B | 476 | 562 | DE |  | 5 | 1 | LS | 3390 | none |
| Patriot | 169 | Unidentified whale | N | 1 | 19-Aug | 23:20 | B | 584 | 656 | DE |  | 4 | 1 | LS | 3390 | none |
| Patriot | 170 | Unidentified pinniped | Y | 1 | 23-Sep | 17:25 | B | 1074 | 1115 | UN | SW | 2 | 1 | LS | 3390 | none |
| Patriot | 171 | Unknown | N | 1 | 30-Jul | 5:13 | C | 150 | 396 | DE |  | 4 | 1 | LS | 3390 | none |
| Torsvik | 30 | Unidentified whale | Y | 1 | 15-Jul | 1:54 | B | 1479 |  | SP | SW | 3 | 45 | TR | 0 | none |
| Torsvik | 31 | Pacific walrus | Y | 2 | 15-Jul | 6:07 | B | 40 | 40 | SP | SW | 3 | 29 | TR | 0 | none |
| Torsvik | 32 | Pacific walrus | N | 1 | 15-Jul | 17:29 | B | 150 | 100 | NO | LO | 4 | 47 | TR | 0 | none |
| Torsvik | 33 | Unidentified seal | N | 1 | 15-Jul | 18:31 | B | 50 | 50 | SP | LO | 3 | 48 | TR | 0 | none |
| Torsvik | 34 | Unidentified seal | N | 1 | 15-Jul | 19:28 | B | 30 | 30 | FL | SW | 3 | 46 | TR | 0 | none |
| Torsvik | 35 | Spotted seal | N | 1 | 15-Jul | 20:32 | B | 80 | 80 | PE | SW | 3 | 46 | TR | 0 | none |
| Torsvik | 36 | Unidentified seal | Y | 1 | 16-Jul | 1:14 | B | 70 | 50 | SP | LO | 3 | 47 | TR | 0 | none |
| Torsvik | 37 | Pacific walrus | Y | 2 | 16-Jul | 20:22 | B | 1188 |  | HO | RE | 2 | 44 | TR | 0 | none |
| Torsvik | 38 | Gray whale | Y | 2 | 16-Jul | 22:16 | B | 466 |  | SP | FD | 2 | 43 | TR | 0 | none |
| Torsvik | 39 | Pacific walrus | N | 1 | 19-Jul | 20:14 | B | 1188 |  | DE |  | 2 | 13 | OT | 0 | none |
| Torsvik | 40 | Bowhead whale | N | 1 | 22-Jul | 3:43 | B | 1188 |  | DE |  | 2 | 53 | TR | 0 | none |
| Torsvik | 41 | Unidentified seal | Y | 1 | 23-Jul | 3:28 | B | 20 | 10 | SA | FD | 5 | 43 | TR | 0 | none |
| Torsvik | 42 | Pacific walrus | N | 1 | 24-Jul | 4:38 | B | 50 | 50 | DE |  | 4 | 49 | TR | 0 | none |
| Torsvik | 43 | Unidentified seal | N | 1 | 24-Jul | 8:10 | B | 10 | 2 | DE |  | 4 | 46 | TR | 0 | none |
| Torsvik | 44 | Unidentified whale | Y | 1 | 24-Jul | 15:39 | B | 1188 |  | SP | BL | 3 | 42 | TR | 0 | none |
| Torsvik | 45 | Pacific walrus | Y | 2 | 24-Jul | 15:47 | B | 466 | 466 | UN | ST | 3 | 43 | TR | 0 | none |
| Torsvik | 46 | Pacific walrus | Y | 1 | 24-Jul | 15:47 | B | 550 | 550 | UN | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 47 | Unidentified dolphin | Y | 1 | 24-Jul | 16:20 | B | 500 | 500 | SP | SW | 3 | 41 | TR | 0 | none |
| Torsvik | 48 | Unidentified dolphin | Y | 1 | 24-Jul | 18:55 | B | 750 |  | SA | PO | 3 | 34 | TR | 0 | none |
| Torsvik | 49 | Pacific walrus | N | 1 | 24-Jul | 19:03 | B | 1000 |  | DE |  | 3 | 34 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 50 | Unidentified seal | Y | 1 | 24-Jul | 21:21 | B | 20 | 20 | SA | TH | 2 | 33 | TR | 0 | none |
| Torsvik | 51 | Unidentified seal | Y | 1 | 24-Jul | 22:17 | B | 400 | 300 | SP | SA | 2 | 37 | TR | 0 | none |
| Torsvik | 52 | Unidentified seal | Y | 1 | 24-Jul | 22:19 | B | 400 | 300 | SP | SA | 2 | 37 | TR | 0 | none |
| Torsvik | 53 | Unidentified dolphin | Y | 2 | 24-Jul | 22:23 | B | 20 | 20 | SA | TH | 2 | 37 | TR | 0 | none |
| Torsvik | 54 | Unidentified seal | Y | 1 | 24-Jul | 22:28 | B | 15 | 15 | SA | FD | 2 | 37 | TR | 0 | none |
| Torsvik | 55 | Unidentified seal | Y | 2 | 24-Jul | 23:01 | B | 250 | 50 | SA | SW | 1 | 38 | TR | 0 | none |
| Torsvik | 56 | Unidentified seal | Y | 10 | 24-Jul | 23:09 | B | 10 | 10 | SA | SW | 1 | 38 | TR | 0 | none |
| Torsvik | 57 | Harbor porpoise | Y | 1 | 24-Jul | 23:18 | B | 300 | 250 | SA | PO | 0 | 38 | TR | 0 | none |
| Torsvik | 58 | Ringed seal | Y | 2 | 25-Jul | 0:01 | B | 100 | 100 | SA | SW | 0 | 36 | TR | 0 | none |
| Torsvik | 59 | Ringed seal | Y | 1 | 25-Jul | 0:05 | B | 150 | 80 | SA | SW | 0 | 36 | TR | 0 | none |
| Torsvik | 60 | Ringed seal | Y | 1 | 25-Jul | 0:10 | B | 80 | 80 | SA | SW | 0 | 36 | TR | 0 | none |
| Torsvik | 61 | Ringed seal | Y | 10 | 25-Jul | 0:13 | B | 160 |  | SA | SW | 0 | 36 | TR | 0 | none |
| Torsvik | 62 | Unidentified seal | Y | 11 | 25-Jul | 0:30 | B | 120 |  | SA | SW | 0 | 35 | TR | 0 | none |
| Torsvik | 63 | Ringed seal | Y | 2 | 25-Jul | 1:06 | B | 50 | 50 | SA | SW | 0 | 33 | TR | 0 | none |
| Torsvik | 64 | Spotted seal | Y | 1 | 25-Jul | 1:08 | B | 20 | 20 | SA | SW | 0 | 33 | TR | 0 | none |
| Torsvik | 65 | Unidentified seal | Y | 1 | 25-Jul | 2:01 | B | 30 | 30 | SA | FE | 0 | 33 | TR | 0 | none |
| Torsvik | 66 | Unidentified seal | Y | 1 | 25-Jul | 2:18 | B | 300 | 300 | SA | FD | 0 | 34 | TR | 0 | none |
| Torsvik | 67 | Unidentified seal | Y | 1 | 25-Jul | 2:21 | B | 100 | 75 | SA | FD | 0 | 35 | TR | 0 | none |
| Torsvik | 68 | Unidentified seal | Y | 1 | 25-Jul | 4:42 | B | 150 | 150 | MI | LO | 1 | 43 | TR | 0 | none |
| Torsvik | 69 | Unidentified seal | Y | 1 | 25-Jul | 4:54 | B | 75 | 75 | SA | SW | 1 | 44 | TR | 0 | none |
| Torsvik | 70 | Unidentified seal | N | 1 | 25-Jul | 13:40 | B | 50 | 50 | SA | SW | 1 | 37 | TR | 0 | none |
| Torsvik | 71 | Unidentified seal | Y | 1 | 25-Jul | 15:35 | B | 20 | 20 | SA | SW | 2 | 39 | TR | 0 | none |
| Torsvik | 72 | Harbor porpoise | Y | 1 | 25-Jul | 15:58 | B | 150 | 130 | ST | SW | 2 | 40 | TR | 0 | none |
| Torsvik | 73 | Unidentified seal | Y | 1 | 25-Jul | 16:46 | B | 350 | 350 | SP | SW | 2 | 40 | TR | 0 | none |
| Torsvik | 74 | Ringed seal | Y | 1 | 25-Jul | 17:06 | B | 150 | 150 | SA | SW | 2 | 39 | TR | 0 | none |
| Torsvik | 75 | Ringed seal | Y | 5 | 25-Jul | 17:12 | B | 130 | 130 | SA | SW | 2 | 39 | TR | 0 | none |
| Torsvik | 76 | Ringed seal | Y | 1 | 25-Jul | 17:43 | B | 50 | 50 | SA | SW | 2 | 37 | TR | 0 | none |
| Torsvik | 77 | Ringed seal | Y | 1 | 25-Jul | 18:14 | B | 75 | 75 | SA | SW | 2 | 37 | TR | 0 | none |
| Torsvik | 78 | Ringed seal | Y | 1 | 25-Jul | 19:24 | B | 70 | 70 | SA | SW | 2 | 36 | TR | 0 | none |
| Torsvik | 79 | Ringed seal | Y | 2 | 25-Jul | 19:27 | B | 70 | 70 | SA | SW | 1 | 36 | TR | 0 | none |
| Torsvik | 80 | Ringed seal | Y | 1 | 25-Jul | 19:49 | B | 80 | 80 | SA | SW | 1 | 36 | TR | 0 | none |
| Torsvik | 81 | Unidentified seal | Y | 1 | 25-Jul | 19:58 | B | 466 |  | SA | SW | 0 | 36 | TR | 0 | none |
| Torsvik | 82 | Unidentified seal | Y | 1 | 25-Jul | 20:03 | B | 404 | 404 | SA | SW | 0 | 36 | TR | 0 | none |
| Torsvik | 83 | Unidentified seal | Y | 1 | 25-Jul | 20:16 | B | 466 |  | PE | SW | 0 | 35 | TR | 0 | none |
| Torsvik | 84 | Unidentified seal | Y | 1 | 25-Jul | 20:21 | B | 244 | 244 | SA | SW | 0 | 35 | TR | 0 | none |
| Torsvik | 85 | Unidentified seal | Y | 1 | 25-Jul | 20:22 | B | 357 | 357 | PE | SW | 1 | 35 | TR | 0 | none |
| Torsvik | 86 | Unidentified seal | Y | 1 | 25-Jul | 20:55 | B | 125 | 116 | ST | SW | 1 | 35 | TR | 0 | none |
| Torsvik | 87 | Unidentified seal | Y | 1 | 25-Jul | 21:14 | B | 100 | 100 | SA | FD | 1 | 35 | TR | 0 | none |
| Torsvik | 88 | Unidentified seal | Y | 1 | 25-Jul | 22:48 | B | 466 | 466 | SA | SW | 2 | 37 | TR | 0 | none |
| Torsvik | 89 | Unidentified seal | Y | 1 | 26-Jul | 2:08 | B | 50 | 30 | SA | LO | 1 | 40 | TR | 0 | none |
| Torsvik | 90 | Pacific walrus | N | 1 | 26-Jul | 2:54 | B | 549 |  | ST | SW | 0 | 39 | TR | 0 | none |
| Torsvik | 91 | Unidentified seal | N | 2 | 26-Jul | 2:55 | B | 357 |  | SP | SW | 0 | 40 | TR | 0 | none |
| Torsvik | 94 | Unidentified seal | Y | 1 | 26-Jul | 3:30 | B | 50 | 50 | SA | SW | 0 | 40 | TR | 0 | none |
| Torsvik | 93 | Unidentified seal | Y | 1 | 26-Jul | 3:30 | B | 50 | 50 | SA | SW | 0 | 40 | TR | 0 | none |
| Torsvik | 92 | Unidentified seal | Y | 1 | 26-Jul | 3:30 | B | 10 | 10 | SP | SW | 0 | 40 | TR | 0 | none |
| Torsvik | 95 | Unidentified seal | Y | 1 | 26-Jul | 3:35 | B | 1188 |  | ST | SW | 1 | 40 | TR | 0 | none |
| Torsvik | 95b | Unidentified seal | Y | 2 | 26-Jul | 3:36 | B | 466 |  | PE | SW | 1 | 40 | TR | 0 | none |
| Torsvik | 97 | Unidentified seal | Y | 1 | 26-Jul | 3:42 | B | 150 | 150 | PE | SW | 1 | 40 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 96 | Unidentified seal | Y | 1 | 26-Jul | 3:42 | B | 150 | 150 | PE | SW | 1 | 40 | TR | 0 | none |
| Torsvik | 98 | Unidentified seal | N | 1 | 26-Jul | 3:49 | B | 30 | 30 | PE | SW | 1 | 40 | TR | 0 | none |
| Torsvik | 99 | Unidentified seal | Y | 1 | 26-Jul | 5:19 | B | 100 | 100 | SP | SW | 0 | 39 | TR | 0 | none |
| Torsvik | 100 | Unidentified seal | Y | 1 | 26-Jul | 5:47 | B | 120 | 120 | SP | SW | 0 | 37 | TR | 0 | none |
| Torsvik | 101 | Ringed seal | Y | 1 | 26-Jul | 5:59 | B | 110 | 110 | ST | SW | 0 | 37 | TR | 0 | none |
| Torsvik | 102 | Unidentified seal | Y | 1 | 26-Jul | 6:29 | B | 75 | 75 | SA | LO | 1 | 37 | TR | 0 | none |
| Torsvik | 103 | Minke whale | Y | 1 | 26-Jul | 7:45 | B | 300 | 300 | SP | BL | 1 | 37 | TR | 0 | none |
| Torsvik | 104 | Unidentified whale | N | 1 | 27-Jul | 11:55 | B | 100 | 2 | DE | | 4 | 34 | TR | 0 | none |
| Torsvik | 105 | Unidentified seal | Y | 1 | 27-Jul | 16:34 | B | 50 | 50 | SP | LO | 6 | 38 | TR | 0 | none |
| Torsvik | 106 | Spotted seal | Y | 1 | 27-Jul | 16:37 | B | 30 | 20 | ST | LO | 6 | 38 | TR | 0 | none |
| Torsvik | 107 | Unidentified seal | Y | 1 | 27-Jul | 16:50 | B | 75 | 75 | SA | SW | 6 | 38 | TR | 0 | none |
| Torsvik | 108 | Unidentified whale | N | 1 | 27-Jul | 21:04 | B | 668 | 3 | DE | | 7 | 37 | TR | 0 | none |
| Torsvik | 109 | Unidentified seal | Y | 1 | 28-Jul | 4:41 | B | 50 | 50 | ST | SW | 6 | 38 | TR | 0 | none |
| Torsvik | 110 | Unidentified seal | Y | 1 | 28-Jul | 5:07 | B | 30 | 30 | SP | SW | 6 | 38 | TR | 0 | none |
| Torsvik | 111 | Ringed seal | Y | 1 | 28-Jul | 17:44 | B | 60 | | SP | SW | 3 | 36 | TR | 0 | none |
| Torsvik | 112 | Ringed seal | Y | 1 | 28-Jul | 18:18 | B | 70 | | SP | SW | 3 | 36 | TR | 0 | none |
| Torsvik | 113 | Unidentified seal | Y | 1 | 28-Jul | 22:28 | B | 100 | 100 | SP | LO | 3 | 37 | TR | 0 | none |
| Torsvik | 114 | Unidentified seal | Y | 1 | 29-Jul | 4:51 | B | 20 | 20 | ST | LO | 4 | 37 | TR | 0 | none |
| Torsvik | 115 | Ringed seal | Y | 1 | 29-Jul | 6:09 | B | 40 | 40 | SA | LO | 4 | 36 | TR | 0 | none |
| Torsvik | 116 | Unidentified seal | N | 2 | 29-Jul | 16:25 | B | 40 | 20 | PE | SW | 1 | 37 | TR | 0 | none |
| Torsvik | 116b | Unidentified seal | N | 1 | 29-Jul | 16:25 | B | 40 | 20 | PE | SW | 1 | 37 | TR | 0 | none |
| Torsvik | 117 | Unidentified seal | N | 1 | 29-Jul | 16:42 | B | 357 | 357 | ST | SW | 0 | 37 | TR | 0 | none |
| Torsvik | 118 | Unidentified seal | N | 1 | 29-Jul | 16:44 | B | 350 | 350 | SP | SW | 0 | 37 | TR | 0 | none |
| Torsvik | 119 | Unidentified seal | N | 1 | 29-Jul | 16:46 | B | 400 | 400 | PE | SW | 0 | 37 | TR | 0 | none |
| Torsvik | 120 | Unidentified seal | N | 1 | 29-Jul | 16:48 | B | 466 | 466 | SP | SW | 0 | 37 | TR | 0 | none |
| Torsvik | 121 | Ringed seal | N | 1 | 29-Jul | 17:04 | B | 60 | 60 | SA | LO | 1 | 36 | TR | 0 | none |
| Torsvik | 122 | Ringed seal | N | 1 | 29-Jul | 17:12 | B | 108 | 108 | SA | LO | 1 | 36 | TR | 0 | none |
| Torsvik | 123 | Ringed seal | N | 1 | 29-Jul | 17:28 | B | 211 | 211 | SA | LO | 1 | 36 | TR | 0 | none |
| Torsvik | 124 | Ringed seal | N | 1 | 29-Jul | 17:29 | B | 70 | 70 | SA | SW | 1 | 36 | TR | 0 | none |
| Torsvik | 125 | Ringed seal | N | 1 | 29-Jul | 17:30 | B | 90 | 90 | SA | SW | 1 | 36 | TR | 0 | none |
| Torsvik | 126 | Ringed seal | N | 1 | 29-Jul | 17:36 | B | 200 | 200 | SA | SW | 1 | 36 | TR | 0 | none |
| Torsvik | 127 | Ringed seal | N | 2 | 29-Jul | 17:36 | B | 150 | 150 | SA | SW | 1 | 36 | TR | 0 | none |
| Torsvik | 128 | Ringed seal | N | 1 | 29-Jul | 17:36 | B | 80 | 80 | SA | SW | 1 | 36 | TR | 0 | none |
| Torsvik | 129 | Ringed seal | N | 1 | 29-Jul | 17:44 | B | 211 | 211 | SP | SW | 1 | 36 | TR | 0 | none |
| Torsvik | 130 | Ringed seal | N | 1 | 29-Jul | 17:49 | B | 100 | 100 | SP | SW | 1 | 36 | TR | 0 | none |
| Torsvik | 131 | Ringed seal | N | 1 | 29-Jul | 17:54 | B | 466 | 466 | SP | SW | 1 | 36 | TR | 0 | none |
| Torsvik | 132 | Ringed seal | Y | 1 | 30-Jul | 0:07 | B | 60 | | SP | SW | 2 | 37 | TR | 0 | none |
| Torsvik | 133 | Ringed seal | Y | 1 | 30-Jul | 0:41 | B | 50 | | SP | SW | 2 | 37 | TR | 0 | none |
| Torsvik | 134 | Harbor porpoise | Y | 1 | 30-Jul | 0:45 | B | 65 | | SA | SW | 2 | 37 | TR | 0 | none |
| Torsvik | 135 | Unidentified seal | Y | 1 | 30-Jul | 4:22 | B | 150 | 150 | SP | SW | 3 | 37 | TR | 0 | none |
| Torsvik | 136 | Unidentified seal | Y | 1 | 30-Jul | 4:28 | B | 100 | 100 | ST | LO | 3 | 37 | TR | 0 | none |
| Torsvik | 137 | Unidentified seal | Y | 1 | 30-Jul | 4:45 | B | 30 | 30 | SA | SW | 3 | 37 | TR | 0 | none |
| Torsvik | 138 | Ringed seal | Y | 2 | 30-Jul | 5:00 | B | 60 | 60 | SP | LO | 3 | 34 | TR | 0 | none |
| Torsvik | 139 | Unidentified dolphin | N | 1 | 30-Jul | 6:05 | B | 65 | | PE | SA | 3 | 36 | TR | 0 | none |
| Torsvik | 140 | Ringed seal | Y | 1 | 31-Jul | 0:05 | B | 40 | 40 | SP | LO | 7 | 37 | TR | 0 | none |
| Torsvik | 141 | Unidentified seal | Y | 1 | 31-Jul | 4:07 | B | 50 | 50 | PE | LO | 6 | 36 | TR | 0 | none |
| Torsvik | 142 | Unidentified seal | Y | 1 | 31-Jul | 5:15 | B | 20 | 20 | SP | SW | 6 | 37 | TR | 0 | none |
| Torsvik | 143 | Ringed seal | Y | 1 | 31-Jul | 17:33 | B | 60 | 60 | SP | LO | 4 | 36 | TR | 0 | none |

TABLE G.4 Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 144 | Ringed seal | Y | 1 | 31-Jul | 19:15 | B | 45 | 45 | SP | LO | 4 | 36 | TR | 0 | none |
| Torsvik | 145 | Unidentified seal | Y | 1 | 31-Jul | 21:06 | B | 15 | 15 | SP | LO | 3 | 37 | TR | 0 | none |
| Torsvik | 146 | Unidentified seal | Y | 1 | 1-Aug | 3:59 | B | 30 | 30 | SP | LO | 3 | 37 | TR | 0 | none |
| Torsvik | 147 | Minke whale | N | 1 | 1-Aug | 4:32 | B | 136 | 136 | PE | BL | 3 | 37 | TR | 0 | none |
| Torsvik | 148 | Ringed seal | Y | 1 | 1-Aug | 4:52 | B | 65 | 65 | PE | LO | 3 | 36 | TR | 0 | none |
| Torsvik | 149 | Unidentified seal | Y | 1 | 3-Aug | 2:47 | B | 200 | 100 | SP | SW | 2 | 26 | TR | 0 | none |
| Torsvik | 150 | Unidentified seal | Y | 1 | 3-Aug | 5:08 | B | 500 | 150 | ST | DI | 0 | 33 | TR | 0 | none |
| Torsvik | 151 | Harbor porpoise | Y | 2 | 3-Aug | 5:23 | B | 400 | 150 | PE | TR | 0 | 34 | TR | 0 | none |
| Torsvik | 152 | Harbor porpoise | Y | 1 | 3-Aug | 5:32 | B | 1500 | 1500 | SA | SW | 0 | 35 | TR | 0 | none |
| Torsvik | 153 | Unidentified seal | Y | 1 | 3-Aug | 5:40 | B | 300 | 200 | SA | LO | 0 | 36 | TR | 0 | none |
| Torsvik | 154 | Unidentified seal | Y | 1 | 3-Aug | 19:33 | B | 150 | 75 | SP | TH | 2 | 37 | TR | 0 | none |
| Torsvik | 155 | Unidentified seal | N | 1 | 4-Aug | 18:46 | C | 150 | 100 | SP | SI | 2 | 45 | TR | 0 | none |
| Torsvik | 156 | Unidentified seal | N | 1 | 4-Aug | 21:44 | B | 100 | 100 | NO | SI | 3 | 43 | TR | 0 | none |
| Torsvik | 157 | Ringed seal | N | 1 | 4-Aug | 23:04 | B | 100 | 40 | SP | SW | 3 | 42 | TR | 0 | none |
| Torsvik | 158 | Bearded seal | N | 1 | 4-Aug | 23:56 | B | 100 | 75 | SA | LO | 3 | 42 | TR | 0 | none |
| Torsvik | 159 | Pacific walrus | Y | 1 | 5-Aug | 18:31 | C | 600 | 600 | UN | UN | 3 | 44 | TR | 0 | none |
| Torsvik | 160 | Unidentified seal | Y | 1 | 5-Aug | 19:06 | C | 100 | 50 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 161 | Unidentified seal | Y | 1 | 5-Aug | 19:34 | C | 200 | 150 | SA | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 162 | Unidentified seal | Y | 1 | 5-Aug | 21:58 | C | 250 | 250 | NO | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 163 | Unidentified seal | Y | 1 | 5-Aug | 22:54 | C | 50 | 50 | FL | FD | 2 | 43 | TR | 0 | none |
| Torsvik | 164 | Unidentified seal | Y | 1 | 5-Aug | 22:58 | C | 226 | 226 | SP | SW | 2 | 43 | TR | 0 | none |
| Torsvik | 165 | Unidentified seal | Y | 1 | 5-Aug | 23:54 | B | 400 | 400 | SA | SW | 1 | 41 | TR | 0 | none |
| Torsvik | 166 | Unidentified seal | Y | 1 | 6-Aug | 0:25 | B | 500 | 500 | SP | SW | 1 | 42 | TR | 0 | none |
| Torsvik | 167 | Unidentified seal | Y | 1 | 6-Aug | 0:35 | B | 750 | 30 | ST | SW | 1 | 42 | TR | 0 | none |
| Torsvik | 168 | Unidentified seal | Y | 1 | 6-Aug | 0:51 | B | 500 | 500 | SP | SW | 1 | 42 | TR | 0 | none |
| Torsvik | 169 | Unidentified seal | Y | 1 | 6-Aug | 0:57 | B | 250 | 250 | PE | SW | 1 | 42 | TR | 0 | none |
| Torsvik | 170 | Unidentified seal | Y | 1 | 6-Aug | 1:05 | B | 600 | 600 | SA | SW | 1 | 42 | TR | 0 | none |
| Torsvik | 171 | Unidentified seal | Y | 1 | 6-Aug | 1:13 | B | 350 | 350 | UN | LG | 1 | 41 | TR | 0 | none |
| Torsvik | 172 | Unidentified seal | Y | 1 | 6-Aug | 1:22 | B | 100 | 50 | SP | SW | 1 | 42 | TR | 0 | none |
| Torsvik | 173 | Unidentified seal | Y | 1 | 6-Aug | 1:24 | B | 450 | 450 | UN | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 174 | Unidentified seal | Y | 1 | 6-Aug | 1:36 | B | 300 | 150 | SP | SW | 1 | 42 | TR | 0 | none |
| Torsvik | 175 | Unidentified seal | Y | 1 | 6-Aug | 1:43 | B | 900 | 900 | SA | SW | 1 | 42 | TR | 0 | none |
| Torsvik | 176 | Unidentified seal | Y | 1 | 6-Aug | 1:51 | B | 75 | 75 | SP | SW | 1 | 41 | TR | 0 | none |
| Torsvik | 177 | Unidentified seal | Y | 1 | 6-Aug | 2:02 | B | 400 | 300 | PE | SW | 1 | 42 | TR | 0 | none |
| Torsvik | 178 | Unidentified seal | Y | 1 | 6-Aug | 2:17 | B | 100 | 100 | SA | SW | 1 | 41 | TR | 0 | none |
| Torsvik | 179 | Unidentified seal | Y | 1 | 6-Aug | 2:37 | B | 300 | 300 | NO | DI | 1 | 41 | TR | 0 | none |
| Torsvik | 180 | Unidentified seal | Y | 1 | 6-Aug | 6:28 | C | 150 | 100 | SP | SW | 3 | 44 | TR | 0 | none |
| Torsvik | 181 | Unidentified seal | Y | 1 | 6-Aug | 14:37 | B | 40 | 40 | SP | SW | 1 | 41 | TR | 0 | none |
| Torsvik | 182 | Ringed seal | Y | 2 | 6-Aug | 14:44 | B | 40 | 40 | NO | SW | 1 | 41 | TR | 0 | none |
| Torsvik | 183 | Unidentified seal | N | 2 | 6-Aug | 15:03 | B | 100 | 50 | PE | SW | 1 | 41 | TR | 0 | none |
| Torsvik | 184 | Unidentified seal | N | 1 | 6-Aug | 15:34 | B | 50 | 25 | NO | SI | 0 | 43 | TR | 0 | none |
| Torsvik | 185 | Unidentified seal | N | 1 | 6-Aug | 15:41 | B | 50 | 50 | NO | SI | 0 | 43 | TR | 0 | none |
| Torsvik | 186 | Unidentified seal | N | 1 | 6-Aug | 19:25 | C | 100 | 10 | ST | TH | 1 | 45 | TR | 0 | none |
| Torsvik | 187 | Pacific walrus | N | 1 | 6-Aug | 19:56 | C | 150 | 150 | NO | SW | 1 | 45 | TR | 0 | none |
| Torsvik | 188 | Unidentified seal | N | 1 | 6-Aug | 20:40 | C | 150 | 75 | NO | LO | 1 | 44 | TR | 0 | none |
| Torsvik | 189 | Unidentified seal | N | 1 | 6-Aug | 21:07 | C | 200 | 180 | PE | SW | 1 | 44 | TR | 0 | none |
| Torsvik | 190 | Ringed seal | Y | 1 | 6-Aug | 23:50 | C | 100 | 50 | NO | FD | 3 | 44 | TR | 0 | none |
| Torsvik | 191 | Unidentified seal | Y | 1 | 7-Aug | 0:50 | B | 100 |  | NO | LO | 4 | 43 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 192 | Unidentified seal | Y | 1 | 7-Aug | 0:53 | B | 100 | | NO | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 193 | Ringed seal | N | 1 | 7-Aug | 4:19 | B | 30 | 30 | SP | SI | 3 | 43 | TR | 0 | none |
| Torsvik | 194 | Ringed seal | N | 1 | 7-Aug | 4:21 | B | 100 | 75 | SP | SI | 3 | 44 | TR | 0 | none |
| Torsvik | 195 | Bearded seal | N | 1 | 7-Aug | 6:37 | B | 60 | 10 | PE | LO | 3 | 42 | TR | 0 | none |
| Torsvik | 196 | Ringed seal | N | 1 | 7-Aug | 6:46 | B | 40 | 30 | SA | SW | 3 | 42 | TR | 0 | none |
| Torsvik | 197 | Ringed seal | Y | 1 | 7-Aug | 15:07 | C | 50 | 25 | NO | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 198 | Unidentified seal | Y | 1 | 7-Aug | 16:17 | B | 20 | 20 | NO | DI | 4 | 43 | TR | 0 | none |
| Torsvik | 199 | Ringed seal | Y | 1 | 7-Aug | 16:27 | B | 75 | 75 | NO | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 200 | Unidentified seal | N | 1 | 7-Aug | 17:27 | B | 100 | 100 | DE | | 4 | 42 | TR | 0 | none |
| Torsvik | 201 | Ringed seal | Y | 1 | 7-Aug | 17:56 | B | 25 | 25 | NO | LO | 4 | 41 | TR | 0 | none |
| Torsvik | 202 | Ringed seal | N | 1 | 7-Aug | 18:27 | B | 50 | 50 | NO | LO | 4 | 42 | TR | 0 | none |
| Torsvik | 203 | Bearded seal | Y | 1 | 7-Aug | 18:53 | B | 50 | 5 | NO | LO | 4 | 41 | TR | 0 | none |
| Torsvik | 204 | Unidentified seal | Y | 1 | 7-Aug | 18:55 | B | 75 | 75 | NO | LO | 4 | 41 | TR | 0 | none |
| Torsvik | 205 | Ringed seal | Y | 1 | 7-Aug | 19:43 | B | 75 | 75 | NO | SW | 4 | 43 | TR | 0 | none |
| Torsvik | 206 | Ringed seal | Y | 1 | 7-Aug | 20:07 | C | 75 | 50 | SA | SW | 4 | 42 | TR | 0 | none |
| Torsvik | 207 | Unidentified seal | Y | 1 | 7-Aug | 20:29 | C | 20 | 15 | SA | SW | 4 | 44 | TR | 0 | none |
| Torsvik | 208 | Unidentified seal | Y | 1 | 7-Aug | 20:46 | C | 50 | 50 | SA | SW | 4 | 44 | TR | 0 | none |
| Torsvik | 209 | Unidentified seal | Y | 1 | 7-Aug | 23:48 | C | 100 | 100 | PE | SW | 4 | 45 | TR | 0 | none |
| Torsvik | 210 | Ringed seal | N | 1 | 8-Aug | 0:57 | C | 30 | 25 | ST | SW | 4 | 44 | TR | 0 | none |
| Torsvik | 211 | Unidentified seal | N | 1 | 8-Aug | 17:29 | C | 75 | 75 | SP | SW | 4 | 44 | TR | 0 | none |
| Torsvik | 212 | Ringed seal | Y | 1 | 8-Aug | 22:43 | C | 150 | 130 | NO | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 213 | Bearded seal | Y | 1 | 9-Aug | 0:09 | C | 100 | 60 | SA | SW | 3 | 44 | TR | 0 | none |
| Torsvik | 214 | Bearded seal | Y | 1 | 9-Aug | 2:33 | C | 100 | 20 | PE | SW | 3 | 44 | TR | 0 | none |
| Torsvik | 215 | Unidentified seal | Y | 1 | 9-Aug | 5:10 | C | 500 | 500 | NO | LG | 2 | 44 | TR | 0 | none |
| Torsvik | 216 | Ringed seal | Y | 1 | 9-Aug | 5:23 | C | 100 | 30 | SP | SW | 2 | 44 | TR | 0 | none |
| Torsvik | 217 | Ringed seal | Y | 1 | 9-Aug | 5:29 | C | 200 | | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 218 | Unidentified seal | Y | 1 | 9-Aug | 5:59 | C | 1000 | 500 | NO | LG | 1 | 44 | TR | 0 | none |
| Torsvik | 219 | Unidentified seal | Y | 1 | 9-Aug | 6:11 | C | 549 | 400 | NO | LG | 1 | 44 | TR | 0 | none |
| Torsvik | 220 | Unidentified seal | Y | 1 | 9-Aug | 6:31 | C | 1500 | 1000 | NO | LO | 1 | 43 | TR | 0 | none |
| Torsvik | 221 | Unidentified seal | Y | 1 | 9-Aug | 15:14 | C | 150 | 120 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 222 | Unidentified seal | Y | 1 | 9-Aug | 17:37 | C | 500 | 500 | SP | SW | 2 | 44 | TR | 0 | none |
| Torsvik | 223 | Bearded seal | Y | 1 | 9-Aug | 18:00 | C | 75 | 75 | SA | SW | 2 | 44 | TR | 0 | none |
| Torsvik | 224 | Unidentified seal | Y | 1 | 9-Aug | 20:18 | B | 357 | 50 | ST | SW | 2 | 41 | TR | 0 | none |
| Torsvik | 225 | Unidentified seal | Y | 1 | 10-Aug | 2:47 | C | 855 | 850 | NO | TH | 2 | 45 | TR | 0 | none |
| Torsvik | 226 | Bearded seal | Y | 1 | 10-Aug | 5:29 | C | 100 | 50 | NO | SW | 2 | 45 | TR | 0 | none |
| Torsvik | 227 | Bearded seal | Y | 1 | 10-Aug | 6:08 | C | 75 | 50 | NO | LG | 2 | 45 | TR | 0 | none |
| Torsvik | 228 | Bearded seal | Y | 1 | 10-Aug | 15:36 | C | 125 | 75 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 229 | Bearded seal | Y | 1 | 10-Aug | 15:44 | C | 150 | 125 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 230 | Unidentified seal | N | 1 | 10-Aug | 16:53 | C | 100 | 80 | SA | SW | 3 | 45 | TR | 0 | none |
| Torsvik | 231 | Ringed seal | Y | 1 | 10-Aug | 17:44 | C | 20 | 20 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 232 | Ringed seal | Y | 1 | 10-Aug | 17:57 | C | 75 | 75 | SA | SW | 2 | 44 | TR | 0 | none |
| Torsvik | 233 | Unidentified seal | N | 1 | 10-Aug | 18:58 | C | 40 | 40 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 234 | Unidentified seal | Y | 1 | 10-Aug | 22:44 | B | 50 | 50 | NO | LO | 4 | 42 | TR | 0 | none |
| Torsvik | 235 | Unidentified seal | Y | 1 | 11-Aug | 0:29 | B | 125 | 125 | NO | LO | 4 | 42 | TR | 0 | none |
| Torsvik | 236 | Ringed seal | Y | 1 | 11-Aug | 5:18 | B | 60 | 30 | SP | SW | 3 | 44 | TR | 0 | none |
| Torsvik | 237 | Ringed seal | Y | 1 | 11-Aug | 5:46 | B | 150 | 75 | SA | SW | 3 | 43 | TR | 0 | none |
| Torsvik | 238 | Bearded seal | Y | 1 | 11-Aug | 15:39 | B | 100 | 50 | ST | LO | 2 | 42 | TR | 0 | none |
| Torsvik | 239 | Unidentified seal | Y | 1 | 11-Aug | 16:59 | B | 40 | 40 | NO | LO | 2 | 43 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 240 | Unidentified seal | Y | 1 | 11-Aug | 17:42 | B | 75 | 75 | NO | LO | 2 | 41 | TR | 0 | none |
| Torsvik | 241 | Ringed seal | Y | 1 | 11-Aug | 21:08 | B | 40 | 20 | ST | LO | 2 | 43 | TR | 0 | none |
| Torsvik | 242 | Unidentified seal | Y | 1 | 11-Aug | 21:45 | B | 30 | 10 | SP | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 243 | Unidentified seal | Y | 1 | 11-Aug | 22:32 | B | 357 | 250 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 244 | Bearded seal | Y | 1 | 11-Aug | 23:10 | B | 466 | 300 | ST | SW | 2 | 45 | TR | 0 | none |
| Torsvik | 245 | Unidentified seal | Y | 2 | 11-Aug | 23:23 | B | 400 | 200 | NO | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 246 | Ringed seal | Y | 1 | 11-Aug | 23:50 | B | 75 | 60 | SA | SW | 2 | 45 | TR | 0 | none |
| Torsvik | 247 | Unidentified seal | Y | 1 | 12-Aug | 18:50 | B | 80 | 80 | NO | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 248 | Ringed seal | N | 1 | 13-Aug | 18:11 | B | 60 | 20 | ST | SW | 4 | 44 | TR | 0 | none |
| Torsvik | 249 | Ringed seal | N | 1 | 13-Aug | 18:22 | B | 50 | 30 | ST | SW | 4 | 44 | TR | 0 | none |
| Torsvik | 250 | Ringed seal | N | 1 | 13-Aug | 19:25 | B | 75 | 15 | ST | SW | 4 | 45 | TR | 0 | none |
| Torsvik | 251 | Ringed seal | N | 1 | 13-Aug | 19:39 | B | 50 | 50 | SA | SW | 4 | 45 | TR | 0 | none |
| Torsvik | 252 | Ringed seal | N | 1 | 13-Aug | 21:10 | B | 75 | 25 | NO | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 253 | Unidentified seal | N | 1 | 13-Aug | 21:22 | B | 20 | 10 | NO | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 254 | Unidentified seal | N | 1 | 13-Aug | 21:51 | B | 30 | 20 | NO | RE | 4 | 44 | TR | 0 | none |
| Torsvik | 255 | Ringed seal | N | 1 | 14-Aug | 3:22 | B | 50 | 30 | ST | LO | 4 | 42 | TR | 0 | none |
| Torsvik | 256 | Ringed seal | N | 1 | 14-Aug | 4:28 | B | 20 | 5 | ST | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 257 | Ringed seal | Y | 1 | 14-Aug | 4:33 | B | 40 | 10 | ST | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 258 | Unidentified seal | Y | 1 | 14-Aug | 4:37 | B | 357 | 350 | NO | LO | 4 | 43 | TR | 0 | none |
| Gulf Provider | 97 | Pacific walrus | N | 3 | 14-Aug | 19:15 | B | 252 | 252 | SP | LO | 2 | 44.2 | TR | 0 | none |
| Gulf Provider | 98 | Unidentified seal | Y | 1 | 15-Aug | 2:28 | B | 163 | 163 | PE | LO | 2 | 42.121 | TR | 0 | none |
| Gulf Provider | 99 | Unidentified seal | Y | 1 | 15-Aug | 4:07 | B | 50 | 50 | SP | LO | 2 | 43.333 | TR | 0 | none |
| Gulf Provider | 100 | Unidentified seal | Y | 1 | 16-Aug | 15:18 | B | 100 | 100 | SP | LO | 2 | 45.152 | TR | 0 | none |
| Gulf Provider | 101 | Unidentified seal | Y | 1 | 16-Aug | 17:36 | B | 382 | 382 | SP | SW | 1 | 42.424 | TR | 0 | none |
| Gulf Provider | 102 | Ringed seal | Y | 1 | 16-Aug | 20:28 | B | 163 | 100 | PE | LO | 1 | 40.303 | TR | 0 | none |
| Gulf Provider | 103 | Unidentified seal | Y | 1 | 16-Aug | 20:44 | B | 179 | 150 | SP | LO | 1 | 39.697 | TR | 0 | none |
| Gulf Provider | 104 | Spotted seal | Y | 1 | 16-Aug | 21:11 | B | 100 | 100 | SP | LO | 1 | 39.697 | TR | 0 | none |
| Gulf Provider | 105 | Unidentified seal | Y | 1 | 16-Aug | 21:21 | B | 100 | 100 | UN | LO | 1 | 39.394 | TR | 0 | none |
| Gulf Provider | 106 | Bearded seal | Y | 1 | 16-Aug | 21:44 | B | 179 | 179 | PE | LO | 1 | 39.394 | TR | 0 | none |
| Gulf Provider | 107 | Unidentified seal | Y | 1 | 16-Aug | 22:00 | B | 252 | 252 | SP | LO | 1 | 40.303 | TR | 0 | none |
| Gulf Provider | 108 | Bearded seal | Y | 1 | 16-Aug | 22:10 | B | 129 | 129 | SA | LO | 1 | 40.606 | TR | 0 | none |
| Gulf Provider | 109 | Unidentified seal | Y | 1 | 16-Aug | 22:48 | B | 50 | 50 | NO | LO | 1 | 41.515 | TR | 0 | none |
| Gulf Provider | 110 | Unidentified seal | Y | 1 | 17-Aug | 0:35 | B | 554 | 554 | UN | SW | 0 | 42.727 | TR | 0 | none |
| Gulf Provider | 111 | Unidentified seal | Y | 1 | 17-Aug | 1:17 | B | 252 | 252 | ST | LO | 1 | 43.03 | TR | 0 | none |
| Gulf Provider | 112 | Spotted seal | Y | 1 | 17-Aug | 2:57 | B | 129 | 100 | SP | LO | 0 | 45.152 | TR | 0 | none |
| Gulf Provider | 113 | Unidentified seal | Y | 1 | 17-Aug | 3:03 | B | 1011 | 1011 | MI | UN | 0 | 44.848 | TR | 0 | none |
| Gulf Provider | 114 | Unidentified seal | Y | 1 | 17-Aug | 3:29 | B | 179 | 179 | SP | LO | 0 | 44.242 | TR | 0 | none |
| Gulf Provider | 115 | Unidentified seal | Y | 1 | 17-Aug | 3:41 | B | 426 | 426 | SP | LO | 0 | 43.636 | TR | 0 | none |
| Gulf Provider | 116 | Unidentified seal | Y | 1 | 17-Aug | 3:52 | B | 222 | 50 | SP | LO | 1 | 43.636 | TR | 0 | none |
| Gulf Provider | 117 | Spotted seal | Y | 2 | 17-Aug | 3:58 | B | 292 | 30 | SP | LO | 1 | 43.333 | TR | 0 | none |
| Gulf Provider | 118 | Unidentified whale | Y | 1 | 17-Aug | 4:18 | B | 2287 | 2287 | PE | SW | 0 | 42.727 | TR | 0 | none |
| Gulf Provider | 119 | Bearded seal | Y | 1 | 17-Aug | 4:55 | B | 346 | 346 | PE | LO | 0 | 42.121 | TR | 0 | none |
| Gulf Provider | 120 | Unidentified seal | Y | 1 | 17-Aug | 5:06 | B | 426 | 426 | SP | SW | 1 | 41.818 | TR | 0 | none |
| Gulf Provider | 121 | Harbor porpoise | Y | 1 | 17-Aug | 5:58 | B | 200 | 200 | SP | SW | 1 | 40.606 | TR | 0 | none |
| Gulf Provider | 122 | Unidentified seal | Y | 1 | 17-Aug | 6:12 | B | 50 | 25 | NO | LO | 1 | 40.303 | TR | 0 | none |
| Gulf Provider | 123 | Unidentified seal | Y | 1 | 17-Aug | 23:51 | B | 50 | 50 | UN | LO | 4 | 42.4 | TR | 0 | none |
| Torsvik | 334 | Unidentified seal | Y | 1 | 19-Aug | 0:21 | B | 80 | 80 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 335 | Ringed seal | N | 1 | 19-Aug | 0:48 | B | 75 | 75 | NO | SW | 4 | 45 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 336 | Unidentified seal | Y | 1 | 19-Aug | 3:09 | B | 50 | 50 | NO | TH | 3 | 43 | TR | 0 | none |
| Torsvik | 337 | Ringed seal | Y | 1 | 19-Aug | 16:15 | B | 25 | 25 | NO | LO | 3 | 42 | TR | 0 | none |
| Torsvik | 338 | Ringed seal | N | 1 | 19-Aug | 18:16 | B | 75 | 40 | PE | SW | 4 | 40 | TR | 0 | none |
| Torsvik | 339 | Unidentified seal | Y | 1 | 19-Aug | 19:05 | B | 40 | 40 | NO | LO | 4 | 40 | TR | 0 | none |
| Torsvik | 340 | Pacific walrus | Y | 1 | 19-Aug | 19:59 | B | 150 | 150 | NO | FD | 4 | 41 | TR | 0 | none |
| Torsvik | 341 | Ringed seal | Y | 1 | 19-Aug | 20:54 | B | 100 | 30 | ST | LO | 4 | 42 | TR | 0 | none |
| Torsvik | 342 | Ringed seal | Y | 1 | 19-Aug | 22:58 | B | 10 | 5 | SA | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 343 | Unidentified whale | N | 1 | 20-Aug | 0:07 | B | 5000 | 10 | DE | | 4 | 45 | TR | 0 | none |
| Torsvik | 344 | Ringed seal | Y | 1 | 20-Aug | 17:49 | B | 75 | 60 | SA | SW | 4 | 43 | TR | 0 | none |
| Torsvik | 345 | Unidentified seal | Y | 1 | 20-Aug | 18:47 | B | 100 | 100 | NO | LO | 4 | 42 | TR | 0 | none |
| Torsvik | 346 | Ringed seal | Y | 1 | 20-Aug | 21:28 | B | 40 | 30 | ST | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 347 | Bearded seal | Y | 1 | 20-Aug | 21:34 | B | 50 | 30 | PE | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 348 | Pacific walrus | Y | 1 | 20-Aug | 22:06 | B | 200 | 80 | SP | SW | 4 | 45 | TR | 0 | none |
| Torsvik | 349 | Unidentified mysticete whale | N | 1 | 20-Aug | 23:52 | B | 2000 | 10 | DE | | 4 | 46 | TR | 0 | none |
| Torsvik | 350 | Unidentified seal | N | 1 | 21-Aug | 1:53 | B | 75 | 75 | NO | SI | 4 | 46 | TR | 0 | none |
| Torsvik | 351 | Unidentified seal | N | 1 | 21-Aug | 2:09 | B | 150 | 100 | SP | SW | 4 | 46 | TR | 0 | none |
| Torsvik | 352 | Pacific walrus | N | 1 | 21-Aug | 2:19 | B | 200 | 150 | SP | SW | 4 | 46 | TR | 0 | none |
| Torsvik | 353 | Pacific walrus | Y | 1 | 21-Aug | 2:49 | B | 40 | 30 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 354 | Pacific walrus | Y | 2 | 21-Aug | 3:14 | B | 30 | 20 | SA | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 355 | Ringed seal | Y | 1 | 21-Aug | 5:59 | B | 40 | 40 | SA | SW | 4 | 44 | TR | 0 | none |
| Torsvik | 356 | Pacific walrus | Y | 1 | 21-Aug | 22:08 | B | 200 | 200 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 357 | Ringed seal | N | 1 | 21-Aug | 23:42 | B | 60 | 25 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 358 | Ringed seal | Y | 1 | 22-Aug | 1:25 | B | 60 | 20 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 359 | Unidentified seal | Y | 1 | 22-Aug | 1:41 | B | 120 | 120 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 360 | Harbor porpoise | N | 1 | 22-Aug | 2:53 | B | 50 | 50 | SP | SW | 4 | 44 | TR | 0 | none |
| Torsvik | 361 | Ringed seal | N | 1 | 22-Aug | 4:27 | B | 50 | 50 | NO | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 362 | Ringed seal | N | 1 | 22-Aug | 5:18 | B | 30 | 20 | SA | SW | 4 | 43 | TR | 0 | none |
| Torsvik | 363 | Ringed seal | Y | 1 | 22-Aug | 17:07 | B | 30 | 20 | NO | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 364 | Bearded seal | Y | 1 | 22-Aug | 19:13 | B | 75 | 50 | PE | SW | 4 | 45 | TR | 0 | none |
| Torsvik | 365 | Ringed seal | N | 1 | 22-Aug | 21:05 | B | 75 | 50 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 366 | Bearded seal | Y | 1 | 22-Aug | 21:56 | B | 75 | 50 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 367 | Unidentified seal | N | 1 | 22-Aug | 22:07 | B | 75 | 60 | SP | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 368 | Unidentified seal | N | 1 | 23-Aug | 1:48 | B | 100 | 100 | SA | SW | 4 | 42 | TR | 0 | none |
| Torsvik | 369 | Ringed seal | Y | 1 | 23-Aug | 2:41 | B | 50 | 50 | SA | FD | 4 | 43 | TR | 0 | none |
| Torsvik | 370 | Bearded seal | N | 1 | 23-Aug | 2:47 | B | 20 | 20 | SA | FD | 4 | 43 | TR | 0 | none |
| Torsvik | 371 | Ringed seal | N | 1 | 23-Aug | 3:00 | B | 75 | 40 | SP | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 372 | Ringed seal | N | 1 | 23-Aug | 4:50 | B | 40 | 40 | NO | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 373 | Ringed seal | Y | 1 | 23-Aug | 5:08 | B | 30 | 30 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 374 | Ringed seal | Y | 2 | 23-Aug | 5:11 | B | 60 | 25 | NO | RA | 4 | 45 | TR | 0 | none |
| Torsvik | 375 | Pacific walrus | Y | 1 | 23-Aug | 5:20 | B | 100 | 100 | SA | SW | 4 | 45 | TR | 0 | none |
| Torsvik | 376 | Ringed seal | Y | 1 | 23-Aug | 5:23 | B | 150 | 100 | SA | SW | 4 | 45 | TR | 0 | none |
| Torsvik | 377 | Ringed seal | N | 1 | 23-Aug | 18:36 | B | 75 | 50 | NO | LO | 3 | 39 | TR | 0 | none |
| Torsvik | 378 | Ringed seal | N | 1 | 23-Aug | 18:47 | B | 80 | 50 | NO | LO | 3 | 40 | TR | 0 | none |
| Torsvik | 379 | Unidentified seal | Y | 1 | 23-Aug | 21:16 | B | 100 | 50 | ST | DI | 3 | 43 | TR | 0 | none |
| Torsvik | 380 | Unidentified seal | Y | 1 | 23-Aug | 21:24 | B | 20 | 20 | PE | TH | 3 | 43 | TR | 0 | none |
| Torsvik | 381 | Ringed seal | Y | 1 | 23-Aug | 21:58 | B | 211 | 200 | SA | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 382 | Ringed seal | Y | 1 | 23-Aug | 22:13 | B | 150 | 50 | ST | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 383 | Ringed seal | Y | 1 | 23-Aug | 22:40 | B | 150 | 75 | ST | LO | 3 | 44 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 384 | Ringed seal | Y | 1 | 23-Aug | 22:56 | B | 357 | 100 | ST | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 385 | Unidentified seal | Y | 1 | 23-Aug | 23:12 | B | 200 | 75 | NO | FD | 3 | 45 | TR | 0 | none |
| Torsvik | 386 | Ringed seal | Y | 1 | 23-Aug | 23:18 | B | 357 | 75 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 387 | Ringed seal | Y | 1 | 23-Aug | 23:23 | B | 70 | 40 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 388 | Ringed seal | Y | 1 | 23-Aug | 23:39 | B | 200 | 150 | NO | FD | 3 | 45 | TR | 0 | none |
| Torsvik | 389 | Pacific walrus | Y | 4 | 23-Aug | 23:48 | B | 357 | 100 | ST | ST | 3 | 45 | TR | 0 | none |
| Torsvik | 390 | Ringed seal | Y | 1 | 24-Aug | 0:15 | B | 100 | 40 | NO | DI | 3 | 45 | TR | 0 | none |
| Torsvik | 391 | Ringed seal | Y | 1 | 24-Aug | 0:22 | B | 70 | 60 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 392 | Ringed seal | Y | 1 | 24-Aug | 0:39 | B | 40 | 25 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 393 | Ringed seal | Y | 1 | 24-Aug | 0:51 | B | 500 | 500 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 394 | Ringed seal | Y | 1 | 24-Aug | 1:21 | B | 668 | 600 | NO | FD | 3 | 45 | TR | 0 | none |
| Torsvik | 395 | Ringed seal | Y | 1 | 24-Aug | 1:27 | B | 50 | 40 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 396 | Ringed seal | Y | 1 | 24-Aug | 2:39 | B | 30 | 30 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 397 | Ringed seal | Y | 1 | 24-Aug | 3:26 | B | 226 | 50 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 398 | Ringed seal | Y | 1 | 24-Aug | 3:35 | B | 244 | 230 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 399 | Ringed seal | Y | 1 | 24-Aug | 16:51 | B | 100 | 100 | NO | LO | 3 | 42 | TR | 0 | none |
| Torsvik | 400 | Ringed seal | Y | 1 | 24-Aug | 17:07 | B | 40 | 20 | NO | SW | 3 | 42 | TR | 0 | none |
| Torsvik | 401 | Ringed seal | Y | 1 | 24-Aug | 19:48 | B | 70 | 40 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 402 | Ringed seal | N | 1 | 24-Aug | 22:13 | B | 40 | 40 | SP | SW | 3 | 45 | TR | 0 | none |
| Torsvik | 403 | Unidentified seal | Y | 1 | 24-Aug | 23:55 | B | 100 | 100 | SP | DI | 4 | 44 | TR | 0 | none |
| Torsvik | 404 | Unidentified seal | Y | 1 | 25-Aug | 0:34 | B | 75 | 75 | NO | SW | 4 | 44 | TR | 0 | none |
| Torsvik | 405 | Ringed seal | Y | 1 | 25-Aug | 1:38 | B | 60 | 25 | ST | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 406 | Ringed seal | N | 1 | 25-Aug | 3:57 | B | 70 | 60 | PE | SW | 4 | 43 | TR | 0 | none |
| Torsvik | 407 | Bearded seal | N | 1 | 25-Aug | 4:16 | B | 20 | 20 | SA | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 408 | Unidentified seal | Y | 1 | 25-Aug | 4:46 | B | 60 | 50 | NO | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 409 | Unidentified seal | Y | 1 | 25-Aug | 5:58 | B | 80 | 80 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 410 | Ringed seal | Y | 1 | 25-Aug | 6:30 | B | 75 | 75 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 411 | Ringed seal | Y | 1 | 25-Aug | 15:38 | B | 75 | 40 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 412 | Ringed seal | Y | 1 | 25-Aug | 15:55 | B | 290 | 280 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 413 | Ringed seal | Y | 2 | 25-Aug | 18:09 | B | 50 | 15 | MI | SW | 3 | 45 | TR | 0 | none |
| Torsvik | 414 | Ringed seal | Y | 1 | 25-Aug | 20:30 | B | 244 | 50 | NO | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 415 | Unidentified seal | Y | 1 | 25-Aug | 21:31 | B | 150 | 130 | NO | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 416 | Ringed seal | Y | 1 | 26-Aug | 0:37 | B | 100 | 80 | NO | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 417 | Pacific walrus | N | 1 | 26-Aug | 2:40 | B | 20 | 20 | SA | FD | 3 | 45 | TR | 0 | none |
| Torsvik | 418 | Pacific walrus | N | 2 | 26-Aug | 3:29 | B | 150 | 50 | ST | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 419 | Ringed seal | N | 1 | 26-Aug | 5:08 | B | 40 | 15 | NO | LG | 3 | 45 | TR | 0 | none |
| Torsvik | 420 | Ringed seal | N | 1 | 26-Aug | 5:40 | B | 75 | 75 | SP | SW | 3 | 44 | TR | 0 | none |
| Torsvik | 421 | Unidentified seal | Y | 1 | 26-Aug | 15:46 | B | 10 | 10 | NO | FD | 3 | 45 | TR | 0 | none |
| Torsvik | 422 | Ringed seal | N | 1 | 26-Aug | 16:43 | B | 75 | 40 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 423 | Bearded seal | N | 1 | 26-Aug | 17:09 | B | 125 | 75 | SA | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 424 | Ringed seal | Y | 1 | 26-Aug | 18:33 | B | 60 | 60 | NO | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 425 | Unidentified seal | Y | 1 | 26-Aug | 19:35 | B | 100 | 100 | SA | FD | 3 | 43 | TR | 0 | none |
| Torsvik | 426 | Unidentified seal | Y | 1 | 26-Aug | 22:02 | B | 75 | 30 | SA | FD | 3 | 45 | TR | 0 | none |
| Torsvik | 427 | Unidentified seal | Y | 1 | 26-Aug | 22:41 | B | 40 | 20 | SP | FD | 3 | 45 | TR | 0 | none |
| Torsvik | 428 | Unidentified seal | N | 1 | 27-Aug | 0:18 | B | 120 | 120 | SA | SW | 3 | 43 | TR | 0 | none |
| Torsvik | 429 | Unidentified seal | N | 1 | 27-Aug | 1:05 | B | 75 | 75 | PE | SW | 3 | 44 | TR | 0 | none |
| Torsvik | 430 | Ringed seal | Y | 1 | 27-Aug | 1:57 | B | 60 | 60 | SA | SW | 3 | 45 | TR | 0 | none |
| Torsvik | 431 | Unidentified seal | Y | 1 | 27-Aug | 2:17 | B | 244 | 240 | SP | DI | 3 | 45 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. (in$^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 432 | Unidentified seal | N | 1 | 27-Aug | 4:20 | B | 30 | 30 | NO | DI | 3 | 43 | TR | 0 | none |
| Torsvik | 433 | Ringed seal | N | 1 | 27-Aug | 18:07 | B | 70 | 70 | PE | SW | 3 | 44 | TR | 0 | none |
| Torsvik | 434 | Unidentified seal | N | 1 | 27-Aug | 18:19 | B | 40 | 25 | PE | SW | 3 | 44 | TR | 0 | none |
| Torsvik | 435 | Pacific walrus | N | 2 | 27-Aug | 18:49 | B | 100 | 50 | PE | ST | 3 | 44 | TR | 0 | none |
| Torsvik | 436 | Unidentified seal | N | 1 | 27-Aug | 19:02 | B | 80 | 70 | ST | SW | 3 | 44 | TR | 0 | none |
| Torsvik | 437 | Unidentified seal | N | 1 | 27-Aug | 19:25 | B | 75 | 30 | ST | SW | 3 | 45 | TR | 0 | none |
| Torsvik | 438 | Ringed seal | N | 1 | 27-Aug | 20:49 | B | 80 | 20 | ST | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 439 | Ringed seal | N | 1 | 27-Aug | 22:07 | B | 20 | 10 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 440 | Ringed seal | N | 1 | 27-Aug | 22:44 | B | 40 | 20 | SA | TH | 3 | 45 | TR | 0 | none |
| Torsvik | 441 | Unidentified seal | N | 1 | 27-Aug | 23:12 | B | 40 | 40 | SA | SW | 3 | 45 | TR | 0 | none |
| Torsvik | 442 | Unidentified seal | Y | 1 | 28-Aug | 1:22 | B | 150 | 125 | ST | SW | 3 | 43 | TR | 0 | none |
| Torsvik | 443 | Ringed seal | Y | 1 | 28-Aug | 1:33 | B | 25 | 25 | NO | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 444 | Ringed seal | N | 1 | 28-Aug | 3:14 | B | 75 | 65 | NO | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 445 | Ringed seal | N | 1 | 28-Aug | 3:31 | B | 75 | 10 | NO | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 446 | Ringed seal | N | 1 | 28-Aug | 3:39 | B | 30 | 30 | SP | SW | 3 | 43 | TR | 0 | none |
| Torsvik | 447 | Bearded seal | N | 1 | 28-Aug | 3:45 | B | 100 | 30 | ST | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 448 | Unidentified seal | N | 1 | 28-Aug | 4:02 | B | 100 | 40 | ST | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 449 | Unidentified seal | N | 1 | 28-Aug | 4:12 | B | 80 | 60 | SP | SW | 3 | 43 | TR | 0 | none |
| Torsvik | 450 | Bearded seal | Y | 1 | 28-Aug | 4:17 | B | 50 | 50 | SA | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 452 | Unidentified seal | Y | 1 | 28-Aug | 4:26 | B | 20 | 20 | NO | TH | 2 | 44 | TR | 0 | none |
| Torsvik | 451 | Ringed seal | Y | 1 | 28-Aug | 4:26 | B | 50 | 20 | ST | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 453 | Unidentified seal | Y | 1 | 28-Aug | 4:45 | B | 200 | 100 | NO | RE | 2 | 43 | TR | 0 | none |
| Torsvik | 454 | Unidentified seal | Y | 2 | 28-Aug | 4:58 | B | 60 | 40 | NO | RE | 2 | 43 | TR | 0 | none |
| Torsvik | 455 | Ringed seal | Y | 1 | 28-Aug | 4:59 | B | 50 | 30 | NO | LO | 2 | 43 | TR | 0 | none |
| Torsvik | 456 | Ringed seal | Y | 1 | 28-Aug | 5:02 | B | 75 | 40 | ST | SW | 2 | 44 | TR | 0 | none |
| Torsvik | 457 | Ringed seal | Y | 1 | 28-Aug | 5:24 | B | 80 | 50 | SP | SW | 2 | 45 | TR | 0 | none |
| Torsvik | 458 | Ringed seal | Y | 1 | 28-Aug | 5:30 | B | 50 | 40 | NO | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 459 | Unidentified seal | Y | 1 | 28-Aug | 5:32 | B | 100 | 100 | SA | SW | 2 | 44 | TR | 0 | none |
| Torsvik | 460 | Unidentified seal | N | 1 | 28-Aug | 5:45 | B | 300 | 200 | ST | SW | 2 | 45 | TR | 0 | none |
| Torsvik | 461 | Unidentified seal | N | 1 | 28-Aug | 5:50 | B | 350 | 300 | NO | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 462 | Unidentified seal | N | 1 | 28-Aug | 6:05 | B | 300 | 300 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 463 | Ringed seal | Y | 1 | 28-Aug | 6:22 | B | 20 | 20 | NO | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 464 | Ringed seal | Y | 1 | 28-Aug | 6:22 | B | 80 | 70 | NO | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 465 | Ringed seal | Y | 1 | 28-Aug | 15:44 | B | 5 | 5 | SA | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 466 | Unidentified seal | Y | 1 | 28-Aug | 15:48 | B | 466 | 450 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 467 | Unidentified seal | N | 1 | 28-Aug | 16:08 | B | 250 | 50 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 468 | Ringed seal | Y | 1 | 28-Aug | 16:19 | B | 50 | 20 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 469 | Unidentified seal | Y | 1 | 28-Aug | 16:23 | B | 75 | 60 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 470 | Ringed seal | N | 1 | 28-Aug | 18:21 | B | 30 | 20 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 471 | Ringed seal | Y | 1 | 28-Aug | 19:57 | B | 40 | 40 | SA | SW | 3 | 45 | TR | 0 | none |
| Torsvik | 472 | Unidentified seal | Y | 1 | 28-Aug | 20:07 | B | 100 | 100 | SA | TH | 3 | 45 | TR | 0 | none |
| Torsvik | 473 | Ringed seal | Y | 1 | 28-Aug | 20:15 | B | 10 | 10 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 474 | Bearded seal | Y | 1 | 28-Aug | 20:29 | B | 100 | 100 | SP | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 475 | Ringed seal | Y | 1 | 28-Aug | 20:54 | B | 50 | 50 | SA | SW | 3 | 44 | TR | 0 | none |
| Torsvik | 476 | Ringed seal | Y | 1 | 28-Aug | 21:27 | B | 75 | 40 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 477 | Ringed seal | Y | 2 | 28-Aug | 21:31 | B | 75 | 25 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 478 | Bearded seal | Y | 1 | 28-Aug | 21:34 | B | 75 | 25 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 479 | Ringed seal | Y | 1 | 28-Aug | 21:36 | B | 75 | 20 | NO | LO | 3 | 44 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 480 | Ringed seal | Y | 1 | 28-Aug | 21:37 | B | 75 | 40 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 481 | Ringed seal | Y | 1 | 28-Aug | 23:24 | B | 70 | 70 | SP | LO | 2 | 43 | TR | 0 | none |
| Torsvik | 482 | Unidentified seal | Y | 1 | 29-Aug | 0:22 | B | 15 | 15 | NO | LO | 2 | 42 | TR | 0 | none |
| Torsvik | 483 | Ringed seal | Y | 1 | 29-Aug | 0:36 | B | 466 | 300 | ST | SW | 2 | 42 | TR | 0 | none |
| Torsvik | 484 | Bearded seal | Y | 1 | 29-Aug | 0:55 | B | 300 | 200 | SA | SW | 3 | 43 | TR | 0 | none |
| Torsvik | 485 | Unidentified seal | Y | 1 | 29-Aug | 1:51 | B | 100 | 100 | SA | SW | 3 | 44 | TR | 0 | none |
| Torsvik | 486 | Unidentified seal | Y | 1 | 29-Aug | 1:54 | B | 75 | 60 | NO | RA | 3 | 44 | TR | 0 | none |
| Torsvik | 487 | Unidentified seal | Y | 1 | 29-Aug | 1:56 | B | 80 | 80 | SA | PO | 3 | 44 | TR | 0 | none |
| Torsvik | 488 | Unidentified seal | Y | 1 | 29-Aug | 2:30 | B | 357 | 350 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 489 | Unidentified seal | Y | 1 | 29-Aug | 3:09 | B | 550 | 500 | ST | SW | 3 | 45 | TR | 0 | none |
| Torsvik | 490 | Bearded seal | Y | 1 | 29-Aug | 3:19 | B | 200 | 100 | ST | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 491 | Bearded seal | Y | 1 | 29-Aug | 3:31 | B | 100 | 50 | ST | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 492 | Pacific walrus | Y | 1 | 29-Aug | 3:42 | B | 100 | 100 | HO | RE | 3 | 44 | TR | 0 | none |
| Torsvik | 493 | Unidentified seal | Y | 1 | 29-Aug | 4:02 | B | 466 | 450 | SP | SW | 3 | 44 | TR | 0 | none |
| Torsvik | 494 | Ringed seal | Y | 1 | 29-Aug | 4:24 | B | 70 | 60 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 495 | Unidentified seal | Y | 1 | 29-Aug | 4:50 | B | 466 | 450 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 496 | Ringed seal | Y | 1 | 29-Aug | 5:26 | B | 466 | 450 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 497 | Ringed seal | Y | 1 | 29-Aug | 6:30 | B | 75 | 50 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 498 | Ringed seal | N | 1 | 29-Aug | 16:46 | B | 10 | 5 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 499 | Ringed seal | N | 1 | 29-Aug | 16:48 | B | 30 | 25 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 500 | Ringed seal | Y | 1 | 29-Aug | 17:22 | B | 25 | 25 | SA | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 501 | Ringed seal | Y | 1 | 29-Aug | 18:38 | B | 75 | 20 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 502 | Ringed seal | N | 1 | 29-Aug | 18:47 | B | 80 | 80 | SP | SW | 4 | 44 | TR | 0 | none |
| Torsvik | 503 | Ringed seal | N | 1 | 29-Aug | 18:51 | B | 150 | 150 | SP | SW | 4 | 44 | TR | 0 | none |
| Torsvik | 504 | Ringed seal | Y | 1 | 29-Aug | 19:17 | B | 75 | 60 | NO | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 505 | Ringed seal | Y | 1 | 29-Aug | 20:30 | B | 75 | 50 | NO | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 506 | Unidentified seal | Y | 1 | 29-Aug | 20:50 | B | 80 | 40 | NO | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 507 | Ringed seal | Y | 1 | 29-Aug | 22:50 | B | 50 | 20 | SP | DI | 4 | 44 | TR | 0 | none |
| Torsvik | 508 | Unidentified seal | Y | 1 | 29-Aug | 23:24 | B | 80 | 80 | NO | FD | 4 | 44 | TR | 0 | none |
| Torsvik | 509 | Ringed seal | Y | 2 | 29-Aug | 23:31 | B | 125 | 50 | ST | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 510 | Ringed seal | Y | 1 | 30-Aug | 0:48 | B | 200 | 150 | ST | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 511 | Ringed seal | Y | 1 | 30-Aug | 1:17 | B | 40 | 40 | SA | FD | 4 | 45 | TR | 0 | none |
| Torsvik | 512 | Ringed seal | N | 1 | 30-Aug | 1:22 | B | 60 | 40 | ST | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 513 | Ringed seal | Y | 1 | 30-Aug | 1:37 | B | 75 | 75 | NO | RA | 4 | 45 | TR | 0 | none |
| Torsvik | 514 | Ringed seal | Y | 1 | 30-Aug | 3:41 | B | 50 | 25 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 515 | Ringed seal | Y | 1 | 30-Aug | 3:43 | B | 50 | 25 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 516 | Unidentified seal | Y | 1 | 30-Aug | 3:56 | B | 400 | 400 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 517 | Pacific walrus | Y | 3 | 30-Aug | 3:59 | B | 549 | 100 | PE | TR | 3 | 44 | TR | 0 | none |
| Torsvik | 518 | Unidentified seal | Y | 1 | 30-Aug | 4:06 | B | 357 | 357 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 521 | Ringed seal | Y | 1 | 30-Aug | 4:17 | B | 20 | 20 | SA | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 520 | Ringed seal | Y | 3 | 30-Aug | 4:17 | B | 100 | 50 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 519 | Unidentified seal | Y | 1 | 30-Aug | 4:17 | B | 550 | 550 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 522 | Ringed seal | Y | 1 | 30-Aug | 4:24 | B | 50 | 20 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 523 | Unidentified seal | Y | 1 | 30-Aug | 4:34 | B | 75 | 75 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 524 | Ringed seal | Y | 1 | 30-Aug | 5:01 | B | 5 | 5 | SA | TR | 3 | 44 | TR | 0 | none |
| Torsvik | 526 | Ringed seal | Y | 1 | 30-Aug | 5:15 | B | 40 | 40 | SA | SW | 3 | 43 | TR | 0 | none |
| Torsvik | 525 | Ringed seal | Y | 1 | 30-Aug | 5:15 | B | 10 | 10 | SA | FD | 3 | 43 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 527 | Unidentified seal | Y | 1 | 30-Aug | 5:17 | B | 150 | 150 | NO | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 528 | Unidentified seal | Y | 1 | 30-Aug | 5:22 | B | 100 | 100 | NO | SI | 3 | 43 | TR | 0 | none |
| Torsvik | 529 | Unidentified seal | Y | 1 | 30-Aug | 5:23 | B | 40 | 40 | SA | SW | 3 | 43 | TR | 0 | none |
| Torsvik | 530 | Ringed seal | Y | 1 | 30-Aug | 5:24 | B | 60 | 30 | ST | SW | 3 | 43 | TR | 0 | none |
| Torsvik | 531 | Unidentified seal | Y | 1 | 30-Aug | 5:27 | B | 250 | 250 | ST | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 532 | Unidentified seal | Y | 1 | 30-Aug | 5:43 | B | 125 | 125 | NO | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 533 | Ringed seal | Y | 1 | 30-Aug | 6:09 | B | 290 | 200 | ST | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 534 | Ringed seal | Y | 1 | 30-Aug | 17:41 | B | 75 | 40 | NO | LO | 3 | 42 | TR | 0 | none |
| Torsvik | 535 | Ringed seal | Y | 1 | 30-Aug | 17:57 | B | 80 | 30 | ST | LO | 3 | 42 | TR | 0 | none |
| Torsvik | 536 | Ringed seal | Y | 1 | 30-Aug | 18:07 | B | 150 | 150 | NO | LO | 3 | 42 | TR | 0 | none |
| Torsvik | 537 | Ringed seal | Y | 1 | 30-Aug | 18:16 | B | 80 | 70 | NO | LO | 3 | 42 | TR | 0 | none |
| Torsvik | 538 | Ringed seal | Y | 1 | 30-Aug | 18:56 | B | 100 | 90 | NO | RA | 3 | 43 | TR | 0 | none |
| Torsvik | 539 | Ringed seal | Y | 1 | 30-Aug | 19:18 | B | 50 | 30 | NO | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 540 | Ringed seal | Y | 1 | 30-Aug | 19:26 | B | 75 | 40 | SA | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 541 | Pacific walrus | Y | 2 | 30-Aug | 19:56 | B | 150 | 50 | NO | SA | 3 | 44 | TR | 0 | none |
| Torsvik | 542 | Ringed seal | Y | 1 | 30-Aug | 19:56 | B | 30 | 30 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 543 | Unidentified seal | Y | 1 | 30-Aug | 20:05 | B | 668 | 668 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 544 | Ringed seal | Y | 1 | 30-Aug | 20:10 | B | 60 | 60 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 545 | Ringed seal | Y | 1 | 30-Aug | 20:12 | B | 100 | 60 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 547 | Ringed seal | Y | 1 | 30-Aug | 20:16 | B | 466 | 60 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 546 | Ringed seal | Y | 1 | 30-Aug | 20:16 | B | 668 | 60 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 548 | Ringed seal | Y | 1 | 30-Aug | 20:35 | B | 75 | 40 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 549 | Ringed seal | Y | 1 | 30-Aug | 21:02 | B | 2 | 2 | SA | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 550 | Ringed seal | Y | 1 | 30-Aug | 21:18 | B | 30 | 30 | SA | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 551 | Unidentified seal | Y | 1 | 30-Aug | 21:27 | B | 25 | 25 | NO | FD | 2 | 45 | TR | 0 | none |
| Torsvik | 552 | Unidentified seal | Y | 1 | 30-Aug | 21:32 | B | 290 | 40 | ST | TH | 2 | 45 | TR | 0 | none |
| Torsvik | 553 | Unidentified seal | Y | 1 | 30-Aug | 21:46 | B | 290 | 290 | UN | UN | 2 | 45 | TR | 0 | none |
| Torsvik | 554 | Ringed seal | Y | 1 | 30-Aug | 22:09 | B | 25 | 10 | ST | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 555 | Unidentified seal | Y | 1 | 30-Aug | 22:25 | B | 150 | 100 | ST | SW | 3 | 45 | TR | 0 | none |
| Torsvik | 556 | Unidentified seal | Y | 1 | 30-Aug | 22:28 | B | 40 | 40 | NO | TH | 3 | 45 | TR | 0 | none |
| Torsvik | 557 | Ringed seal | Y | 1 | 30-Aug | 23:42 | B | 150 | 150 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 558 | Ringed seal | Y | 1 | 31-Aug | 0:10 | B | 250 | 250 | SP | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 559 | Ringed seal | Y | 1 | 31-Aug | 0:16 | B | 60 | 60 | SA | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 560 | Ringed seal | Y | 1 | 31-Aug | 0:16 | B | 20 | 20 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 561 | Ringed seal | Y | 1 | 31-Aug | 0:22 | B | 60 | 15 | ST | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 562 | Ringed seal | Y | 1 | 31-Aug | 0:35 | B | 90 | 80 | ST | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 563 | Unidentified seal | Y | 1 | 31-Aug | 0:37 | B | 80 | 80 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 564 | Unidentified seal | Y | 1 | 31-Aug | 0:41 | B | 80 | 80 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 565 | Ringed seal | Y | 1 | 31-Aug | 0:51 | B | 120 | 120 | NO | RA | 3 | 45 | TR | 0 | none |
| Torsvik | 566 | Ringed seal | Y | 2 | 31-Aug | 0:55 | B | 150 | 100 | ST | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 567 | Ringed seal | Y | 1 | 31-Aug | 1:13 | B | 200 | 200 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 568 | Ringed seal | Y | 1 | 31-Aug | 1:23 | B | 60 | 30 | SP | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 570 | Ringed seal | Y | 1 | 31-Aug | 1:35 | B | 40 | 40 | NO | LO | 2 | 45 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 569 | Unidentified seal | Y | 1 | 31-Aug | 1:35 | B | 357 | 300 | ST | SW | 2 | 45 | TR | 0 | none |
| Torsvik | 571 | Pacific walrus | Y | 3 | 31-Aug | 1:41 | B | 1188 | 250 | PE | TR | 2 | 45 | TR | 0 | none |
| Torsvik | 572 | Ringed seal | Y | 2 | 31-Aug | 1:43 | B | 250 | 225 | ST | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 573 | Ringed seal | Y | 1 | 31-Aug | 1:44 | B | 120 | 120 | NO | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 574 | Ringed seal | Y | 1 | 31-Aug | 1:52 | B | 100 | 10 | ST | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 575 | Ringed seal | Y | 1 | 31-Aug | 1:56 | B | 80 | 70 | NO | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 576 | Ringed seal | Y | 3 | 31-Aug | 2:00 | B | 100 | 20 | ST | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 577 | Ringed seal | Y | 1 | 31-Aug | 2:03 | B | 100 | 50 | SP | SW | 2 | 45 | TR | 0 | none |
| Torsvik | 578 | Ringed seal | Y | 1 | 31-Aug | 2:04 | B | 200 | 100 | NO | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 579 | Ringed seal | Y | 1 | 31-Aug | 2:04 | B | 100 | 10 | NO | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 580 | Ringed seal | Y | 1 | 31-Aug | 2:10 | B | 75 | 50 | NO | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 581 | Pacific walrus | Y | 5 | 31-Aug | 2:15 | B | 668 | 668 | SA | MI | 2 | 45 | TR | 0 | none |
| Torsvik | 582 | Unidentified seal | Y | 1 | 31-Aug | 2:26 | B | 100 | 100 | NO | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 583 | Harbor porpoise | Y | 1 | 31-Aug | 2:41 | B | 150 | 100 | SP | SW | 2 | 45 | TR | 0 | none |
| Torsvik | 584 | Ringed seal | Y | 1 | 31-Aug | 2:55 | B | 75 | 75 | NO | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 585 | Ringed seal | Y | 1 | 31-Aug | 3:16 | B | 50 | 50 | NO | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 586 | Unidentified seal | Y | 1 | 31-Aug | 3:18 | B | 357 | 200 | NO | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 587 | Ringed seal | Y | 1 | 31-Aug | 3:20 | B | 20 | 20 | NO | TH | 2 | 45 | TR | 0 | none |
| Torsvik | 589 | Unidentified whale | Y | 1 | 31-Aug | 3:28 | B | 400 | 400 | NO | DI | 1 | 45 | TR | 0 | none |
| Torsvik | 588 | Unidentified seal | Y | 1 | 31-Aug | 3:30 | B | 668 | 600 | NO | LO | 2 | 45 | TR | 0 | none |
| Torsvik | 590 | Unidentified seal | Y | 1 | 31-Aug | 3:39 | B | 357 | 350 | NO | UN | 1 | 44 | TR | 0 | none |
| Torsvik | 591 | Unidentified seal | Y | 2 | 31-Aug | 4:06 | B | 466 | 466 | NO | UN | 1 | 44 | TR | 0 | none |
| Torsvik | 592 | Unidentified seal | Y | 1 | 31-Aug | 4:11 | B | 300 | 300 | SA | SW | 1 | 44 | TR | 0 | none |
| Torsvik | 593 | Ringed seal | Y | 1 | 31-Aug | 4:12 | B | 50 | 50 | SP | DI | 1 | 44 | TR | 0 | none |
| Torsvik | 594 | Ringed seal | Y | 2 | 31-Aug | 4:15 | B | 357 | 357 | NO | LO | 0 | 43 | TR | 0 | none |
| Torsvik | 596 | Ringed seal | Y | 1 | 31-Aug | 4:18 | B | 5 | 5 | NO | FD | 0 | 43 | TR | 0 | none |
| Torsvik | 595 | Ringed seal | Y | 1 | 31-Aug | 4:18 | B | 50 | 40 | NO | RE | 0 | 43 | TR | 0 | none |
| Torsvik | 597 | Ringed seal | Y | 1 | 31-Aug | 4:20 | B | 50 | 50 | SP | DI | 0 | 43 | TR | 0 | none |
| Torsvik | 598 | Unidentified seal | Y | 2 | 31-Aug | 4:29 | B | 357 | 350 | NO | UN | 0 | 43 | TR | 0 | none |
| Torsvik | 599 | Unidentified seal | Y | 1 | 31-Aug | 4:53 | B | 100 | 100 | SP | SI | 0 | 43 | TR | 0 | none |
| Torsvik | 600 | Ringed seal | Y | 1 | 31-Aug | 4:57 | B | 75 | 60 | NO | LO | 0 | 43 | TR | 0 | none |
| Torsvik | 601 | Ringed seal | Y | 1 | 31-Aug | 5:22 | B | 70 | 50 | NO | RA | 0 | 42 | TR | 0 | none |
| Torsvik | 602 | Unidentified seal | Y | 1 | 31-Aug | 5:30 | B | 300 | 200 | NO | LO | 0 | 42 | TR | 0 | none |
| Torsvik | 603 | Ringed seal | Y | 2 | 31-Aug | 5:37 | B | 100 | 25 | SP | LO | 0 | 43 | TR | 0 | none |
| Torsvik | 604 | Unidentified seal | Y | 2 | 31-Aug | 5:51 | B | 100 | 100 | NO | LO | 0 | 43 | TR | 0 | none |
| Torsvik | 605 | Ringed seal | Y | 1 | 31-Aug | 5:55 | B | 250 | 40 | NO | LO | 0 | 45 | TR | 0 | none |
| Torsvik | 606 | Unidentified seal | Y | 1 | 31-Aug | 5:58 | B | 120 |  | NO | LO | 0 | 45 | TR | 0 | none |
| Torsvik | 607 | Unidentified seal | Y | 1 | 31-Aug | 5:58 | B | 120 |  | NO | LO | 0 | 45 | TR | 0 | none |
| Torsvik | 608 | Unidentified seal | Y | 1 | 31-Aug | 5:59 | B | 120 |  | NO | LO | 0 | 45 | TR | 0 | none |
| Torsvik | 609 | Unidentified seal | Y | 1 | 31-Aug | 6:00 | B | 120 |  | NO | LO | 0 | 45 | TR | 0 | none |
| Torsvik | 610 | Unidentified seal | Y | 1 | 31-Aug | 6:00 | B | 120 |  | NO | LO | 0 | 45 | TR | 0 | none |
| Torsvik | 611 | Unidentified seal | Y | 1 | 31-Aug | 6:01 | B | 120 |  | NO | LO | 0 | 45 | TR | 0 | none |
| Torsvik | 612 | Unidentified seal | Y | 2 | 31-Aug | 6:02 | B | 120 |  | NO | LO | 0 | 45 | TR | 0 | none |
| Torsvik | 613 | Unidentified seal | Y | 1 | 31-Aug | 6:02 | B | 120 |  | NO | LO | 0 | 45 | TR | 0 | none |
| Torsvik | 614 | Unidentified seal | Y | 1 | 31-Aug | 6:03 | B | 120 |  | NO | LO | 0 | 45 | TR | 0 | none |
| Torsvik | 615 | Unidentified seal | Y | 1 | 31-Aug | 6:03 | B | 120 |  | NO | LO | 0 | 45 | TR | 0 | none |
| Torsvik | 616 | Unidentified seal | Y | 1 | 31-Aug | 6:03 | B | 120 |  | NO | LO | 0 | 45 | TR | 0 | none |
| Torsvik | 617 | Unidentified seal | Y | 2 | 31-Aug | 6:04 | B | 120 |  | NO | LO | 0 | 45 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 618 | Unidentified seal | Y | 2 | 31-Aug | 6:05 | B | 120 | | NO | LO | 0 | 1 | TR | 0 | none |
| Torsvik | 619 | Ringed seal | Y | 1 | 31-Aug | 6:08 | B | 150 | 150 | NO | LO | 0 | 1 | TR | 0 | none |
| Torsvik | 620 | Ringed seal | Y | 1 | 31-Aug | 6:08 | B | 100 | 100 | SA | SW | 0 | 1 | TR | 0 | none |
| Torsvik | 622 | Unidentified seal | Y | 2 | 31-Aug | 6:16 | B | 150 | 150 | SP | SW | 0 | 43 | TR | 0 | none |
| Torsvik | 621 | Unidentified seal | Y | 2 | 31-Aug | 6:16 | B | 150 | 150 | NO | SW | 0 | 43 | TR | 0 | none |
| Torsvik | 623 | Ringed seal | Y | 1 | 31-Aug | 6:19 | B | 100 | 100 | NO | LO | 0 | 43 | TR | 0 | none |
| Torsvik | 624 | Unidentified seal | Y | 1 | 31-Aug | 6:22 | B | 100 | 50 | SP | SW | 0 | 43 | TR | 0 | none |
| Torsvik | 625 | Unidentified seal | Y | 1 | 31-Aug | 6:25 | B | 450 | 200 | SA | SW | 0 | 43 | TR | 0 | none |
| Torsvik | 626 | Unidentified seal | Y | 1 | 31-Aug | 6:25 | B | 100 | 100 | NO | LO | 0 | 43 | TR | 0 | none |
| Torsvik | 627 | Unidentified seal | Y | 1 | 31-Aug | 6:29 | B | 500 | 500 | NO | LO | 0 | 1 | TR | 0 | none |
| Torsvik | 628 | Unidentified seal | Y | 1 | 31-Aug | 6:29 | B | 75 | 75 | NO | SI | 0 | 1 | TR | 0 | none |
| Torsvik | 629 | Ringed seal | Y | 1 | 31-Aug | 16:01 | B | 40 | 35 | NO | LO | 4 | 42 | TR | 0 | none |
| Torsvik | 630 | Unidentified seal | Y | 2 | 31-Aug | 17:02 | B | 10 | 10 | NO | TH | 4 | 43 | TR | 0 | none |
| Torsvik | 631 | Ringed seal | Y | 1 | 31-Aug | 17:08 | B | 30 | 30 | SA | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 632 | Ringed seal | Y | 1 | 31-Aug | 17:29 | B | 70 | 30 | SA | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 633 | Ringed seal | Y | 1 | 31-Aug | 17:37 | B | 400 | 25 | SP | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 634 | Ringed seal | Y | 1 | 31-Aug | 17:46 | B | 75 | 75 | NO | RA | 4 | 43 | TR | 0 | none |
| Torsvik | 635 | Ringed seal | Y | 1 | 31-Aug | 18:04 | B | 70 | 40 | ST | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 636 | Ringed seal | Y | 1 | 31-Aug | 18:07 | B | 60 | 30 | SP | SW | 4 | 44 | TR | 0 | none |
| Torsvik | 637 | Ringed seal | Y | 1 | 31-Aug | 18:07 | B | 40 | 40 | NO | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 638 | Ringed seal | Y | 1 | 31-Aug | 18:09 | B | 75 | 75 | NO | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 639 | Ringed seal | Y | 1 | 31-Aug | 18:10 | B | 50 | 50 | SA | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 640 | Ringed seal | Y | 1 | 31-Aug | 18:13 | B | 40 | 40 | NO | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 641 | Ringed seal | Y | 1 | 31-Aug | 18:13 | B | 10 | 10 | SP | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 642 | Ringed seal | Y | 1 | 31-Aug | 19:34 | B | 75 | 40 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 643 | Ringed seal | Y | 1 | 31-Aug | 19:36 | B | 80 | 60 | ST | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 644 | Ringed seal | Y | 1 | 31-Aug | 19:38 | B | 80 | 50 | NO | RA | 4 | 45 | TR | 0 | none |
| Torsvik | 645 | Ringed seal | Y | 1 | 31-Aug | 20:12 | B | 50 | 20 | ST | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 646 | Ringed seal | Y | 1 | 31-Aug | 20:15 | B | 25 | 25 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 647 | Ringed seal | Y | 2 | 31-Aug | 20:29 | B | 30 | 30 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 648 | Ringed seal | Y | 1 | 31-Aug | 21:17 | B | 30 | 20 | SP | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 649 | Unidentified seal | Y | 1 | 31-Aug | 21:21 | B | 40 | 40 | NO | SI | 4 | 45 | TR | 0 | none |
| Torsvik | 650 | Unidentified seal | Y | 1 | 31-Aug | 23:09 | B | 100 | 100 | SA | SW | 4 | 45 | TR | 0 | none |
| Torsvik | 651 | Pacific walrus | Y | 2 | 31-Aug | 23:18 | B | 100 | 100 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 652 | Ringed seal | Y | 1 | 1-Sep | 0:01 | B | 50 | 20 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 653 | Ringed seal | Y | 1 | 1-Sep | 5:11 | B | 15 | 15 | NO | LO | 5 | 44 | TR | 0 | none |
| Torsvik | 654 | Unidentified seal | Y | 1 | 1-Sep | 15:32 | B | 20 | 20 | NO | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 655 | Ringed seal | Y | 1 | 1-Sep | 15:47 | B | 10 | 10 | NO | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 656 | Ringed seal | Y | 2 | 1-Sep | 16:01 | B | 75 | 50 | NO | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 657 | Ringed seal | Y | 1 | 1-Sep | 17:31 | B | 30 | 20 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 658 | Unidentified seal | Y | 1 | 1-Sep | 18:09 | B | 40 | 40 | NO | FD | 4 | 45 | TR | 0 | none |
| Torsvik | 659 | Ringed seal | Y | 1 | 1-Sep | 18:16 | B | 70 | 10 | SP | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 660 | Ringed seal | Y | 1 | 1-Sep | 18:24 | B | 75 | 75 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 661 | Ringed seal | Y | 1 | 1-Sep | 18:49 | B | 75 | 30 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 662 | Ringed seal | Y | 1 | 1-Sep | 19:02 | B | 60 | 60 | NO | TH | 4 | 45 | TR | 0 | none |
| Torsvik | 663 | Ringed seal | N | 2 | 1-Sep | 19:35 | B | 40 | 40 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 664 | Unidentified seal | Y | 1 | 1-Sep | 20:16 | B | 20 | 15 | NO | LO | 4 | 45 | TR | 0 | none |
| Torsvik | 665 | Unidentified seal | Y | 1 | 1-Sep | 20:36 | B | 80 | 50 | NO | LO | 4 | 45 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. (in$^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 666 | Unidentified seal | Y | 1 | 1-Sep | 21:57 | B | 25 | 25 | NO | SI | 5 | 44 | TR | 0 | none |
| Torsvik | 667 | Unidentified seal | Y | 1 | 1-Sep | 22:03 | B | 25 | 25 | NO | SI | 5 | 44 | TR | 0 | none |
| Torsvik | 668 | Pacific walrus | Y | 1 | 1-Sep | 22:09 | B | 150 | 150 | NO | LO | 5 | 44 | TR | 0 | none |
| Torsvik | 669 | Ringed seal | Y | 1 | 1-Sep | 23:14 | B | 60 | 50 | NO | LO | 5 | 42 | TR | 0 | none |
| Torsvik | 670 | Ringed seal | Y | 2 | 2-Sep | 0:00 | B | 75 | 60 | NO | LO | 5 | 41 | TR | 0 | none |
| Torsvik | 671 | Ringed seal | Y | 1 | 2-Sep | 0:06 | B | 70 | 70 | NO | LO | 5 | 41 | TR | 0 | none |
| Torsvik | 673 | Ringed seal | Y | 1 | 2-Sep | 0:36 | B | 200 | 100 | ST | LO | 4 | 41 | TR | 0 | none |
| Torsvik | 672 | Pacific walrus | Y | 1 | 2-Sep | 0:36 | B | 200 | 200 | NO | DI | 4 | 41 | TR | 0 | none |
| Torsvik | 674 | Ringed seal | Y | 1 | 2-Sep | 0:52 | B | 30 | 10 | NO | LO | 4 | 40 | TR | 0 | none |
| Torsvik | 675 | Ringed seal | N | 1 | 2-Sep | 1:54 | B | 60 | 60 | SA | SW | 4 | 43 | TR | 0 | none |
| Torsvik | 676 | Unidentified seal | N | 1 | 2-Sep | 2:34 | B | 60 | 60 | NO | SI | 4 | 43 | TR | 0 | none |
| Torsvik | 677 | Unidentified seal | N | 1 | 2-Sep | 3:16 | B | 100 | 100 | NO | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 678 | Pacific walrus | N | 1 | 2-Sep | 3:48 | B | 75 | 5 | ST | DI | 3 | 44 | TR | 0 | none |
| Torsvik | 679 | Ringed seal | N | 2 | 2-Sep | 4:00 | B | 100 | 75 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 680 | Ringed seal | N | 1 | 2-Sep | 4:00 | B | 100 | 50 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 681 | Ringed seal | N | 1 | 2-Sep | 4:01 | B | 75 | 5 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 682 | Ringed seal | N | 1 | 2-Sep | 4:16 | B | 20 | 5 | SP | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 683 | Unidentified seal | N | 1 | 2-Sep | 4:20 | B | 50 | 50 | NO | RA | 3 | 45 | TR | 0 | none |
| Torsvik | 684 | Ringed seal | N | 1 | 2-Sep | 4:27 | B | 50 | 40 | NO | TH | 2 | 45 | TR | 0 | none |
| Torsvik | 685 | Ringed seal | N | 1 | 2-Sep | 5:04 | B | 50 | 50 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 686 | Ringed seal | N | 1 | 2-Sep | 5:21 | B | 30 | 30 | SA | TH | 2 | 44 | TR | 0 | none |
| Torsvik | 687 | Ringed seal | Y | 1 | 2-Sep | 5:32 | B | 60 | 60 | NO | LO | 2 | 43 | TR | 0 | none |
| Gulf Provider | 258a | Pacific walrus | Y | 2 | 2-Sep | 15:30 | B | 50 | 50 | SA | LO | 4 | 40.606 | TR | 0 | none |
| Gulf Provider | 259a | Spotted seal | Y | 1 | 2-Sep | 17:35 | B | 75 | 75 | NO | LO | 4 | 42.424 | TR | 0 | none |
| Gulf Provider | 260a | Spotted seal | N | 2 | 2-Sep | 20:25 | B | 20 | 20 | NO | FL | 4 | 45.758 | TR | 0 | none |
| Gulf Provider | 261a | Spotted seal | Y | 1 | 2-Sep | 20:34 | B | 20 | 20 | PE | FL | 4 | 45.758 | TR | 0 | none |
| Gulf Provider | 262a | Unidentified seal | Y | 1 | 2-Sep | 21:51 | B | 100 | 100 | PE | FL | 3 | 43.939 | TR | 0 | none |
| Gulf Provider | 263a | Spotted seal | N | 1 | 3-Sep | 3:22 | B | 100 | 100 | PE | DI | 5 | 39.697 | TR | 0 | none |
| Gulf Provider | 264a | Spotted seal | N | 1 | 3-Sep | 3:28 | B | 200 | 200 | PE | DI | 5 | 40.606 | TR | 0 | none |
| Gulf Provider | 265a | Unidentified pinniped | Y | 1 | 4-Sep | 4:43 | B | 120 | 120 | UN | LO | 6 | 42.424 | TR | 0 | none |
| Gulf Provider | 266a | Unidentified pinniped | N | 1 | 4-Sep | 19:42 | B | 130 | 130 | SP | DI | 7 | 42.727 | TR | 0 | none |
| Gulf Provider | 267a | Spotted seal | Y | 1 | 7-Sep | 2:39 | B | 129 | 50 | MI | LO | 5 | 43.939 | TR | 0 | none |
| Gulf Provider | 268a | Spotted seal | Y | 1 | 7-Sep | 17:21 | B | 30 | 10 | MI | LO | 6 | 42.424 | TR | 0 | none |
| Gulf Provider | 269a | Spotted seal | Y | 1 | 7-Sep | 18:53 | B | 50 | 50 | UN | LO | 6 | 45.455 | TR | 0 | none |
| Gulf Provider | 270a | Unidentified seal | N | 1 | 8-Sep | 19:12 | B | 252 | 252 | SP | LO | 7 | 42.121 | TR | 0 | none |
| Gulf Provider | 271a | Spotted seal | N | 1 | 8-Sep | 22:55 | B | 200 | 200 | NO | LO | 6 | 44.848 | TR | 0 | none |
| Gulf Provider | 272a | Spotted seal | N | 1 | 8-Sep | 23:25 | B | 200 | 200 | SA | LO | 6 | 45.455 | TR | 0 | none |
| Gulf Provider | 273a | Spotted seal | N | 1 | 8-Sep | 23:42 | B | 200 | 200 | SA | LO | 6 | 45.455 | TR | 0 | none |
| Gulf Provider | 274a | Spotted seal | Y | 1 | 9-Sep | 19:21 | B | 75 | 50 | SP | TH | 4 | 41.212 | TR | 0 | none |
| Gulf Provider | 275a | Unidentified seal | Y | 1 | 10-Sep | 6:07 | B | 75 | 75 | MI | LO | 3 | 40 | TR | 0 | none |
| Gulf Provider | 276a | Unidentified seal | Y | 1 | 10-Sep | 19:11 | B | 40 | 40 | SP | TH | 5 | 40.909 | TR | 0 | none |
| Torsvik | 950 | Unidentified seal | N | 1 | 12-Sep | 16:56 | B | 100 | 100 | NO | LO | 4 | 1 | TR | 0 | none |
| Torsvik | 951 | Unidentified seal | N | 1 | 12-Sep | 21:22 | B | 100 | 90 | NO | LO | 3 | 43 | TR | 0 | none |
| Torsvik | 952 | Unidentified seal | N | 1 | 13-Sep | 3:47 | B | 30 | 30 | SP | SW | 5 | 43 | TR | 0 | none |
| Torsvik | 953 | Pacific walrus | Y | 1 | 13-Sep | 16:08 | C | 80 | 40 | NO | LO | 5 | 1 | TR | 0 | none |
| Torsvik | 954 | Pacific walrus | Y | 1 | 13-Sep | 16:22 | C | 30 | 30 | SP | LO | 5 | 1 | TR | 0 | none |
| Torsvik | 955 | Pacific walrus | N | 1 | 13-Sep | 16:38 | C | 60 | 60 | NO | RE | 5 | 1 | TR | 0 | none |
| Torsvik | 956 | Pacific walrus | N | 1 | 13-Sep | 16:53 | C | 100 | 100 | SA | SW | 5 | 1 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 957 | Pacific walrus | N | 1 | 13-Sep | 17:04 | C | 90 | 80 | SA | LO | 5 | 42 | TR | 0 | none |
| Torsvik | 958 | Unidentified seal | N | 1 | 13-Sep | 19:43 | C | 40 | 20 | NO | LO | 5 | 42 | TR | 0 | none |
| Torsvik | 959 | Ringed seal | Y | 1 | 14-Sep | 20:23 | C | 50 | 30 | MI | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 960 | Unidentified seal | Y | 1 | 14-Sep | 21:35 | C | 50 | 50 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 961 | Unidentified seal | Y | 1 | 14-Sep | 21:35 | C | 130 | 100 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 962 | Ringed seal | Y | 1 | 14-Sep | 22:01 | C | 60 | 40 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 963 | Ringed seal | Y | 1 | 14-Sep | 22:08 | C | 100 | 60 | MI | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 964 | Ringed seal | Y | 1 | 14-Sep | 22:09 | C | 60 | 40 | MI | LO | 3 | 46 | TR | 0 | none |
| Torsvik | 965 | Ringed seal | Y | 1 | 14-Sep | 22:51 | C | 40 | 40 | NO | LO | 3 | 45 | TR | 0 | none |
| Torsvik | 966 | Ringed seal | Y | 1 | 14-Sep | 23:46 | C | 60 | 50 | NO | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 967 | Ringed seal | Y | 1 | 14-Sep | 23:54 | C | 45 | 40 | SA | LO | 3 | 44 | TR | 0 | none |
| Torsvik | 968 | Ringed seal | Y | 1 | 15-Sep | 3:45 | B | 20 | 10 | MI | LO | 2 | 41 | TR | 0 | none |
| Torsvik | 969 | Ringed seal | Y | 1 | 15-Sep | 4:17 | B | 130 | 20 | MI | LO | 2 | 41 | TR | 0 | none |
| Torsvik | 970 | Ringed seal | Y | 1 | 15-Sep | 4:51 | B | 30 | 20 | SA | LO | 2 | 41 | TR | 0 | none |
| Torsvik | 971 | Ringed seal | Y | 1 | 15-Sep | 15:57 | B | 20 | 20 | SA | SW | 1 | 1 | TR | 0 | none |
| Torsvik | 972 | Unidentified seal | Y | 1 | 15-Sep | 16:03 | B | 80 | 80 | SA | LO | 1 | 1 | TR | 0 | none |
| Torsvik | 973 | Unidentified seal | Y | 1 | 15-Sep | 16:47 | B | 80 | 80 | NO | LO | 2 | 1 | TR | 0 | none |
| Torsvik | 974 | Ringed seal | Y | 2 | 15-Sep | 20:46 | B | 50 | 20 | MI | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 975 | Unidentified seal | Y | 1 | 15-Sep | 21:23 | B | 200 | 100 | MI | LO | 1 | 43 | TR | 0 | none |
| Torsvik | 976 | Pacific walrus | Y | 1 | 15-Sep | 21:25 | B | 100 | 80 | SP | LO | 1 | 43 | TR | 0 | none |
| Torsvik | 977 | Spotted seal | Y | 1 | 15-Sep | 21:28 | B | 60 | 40 | SP | LO | 1 | 43 | TR | 0 | none |
| Torsvik | 978 | Ringed seal | Y | 1 | 15-Sep | 21:29 | B | 80 | 40 | MI | LO | 1 | 43 | TR | 0 | none |
| Torsvik | 979 | Unidentified seal | Y | 1 | 15-Sep | 21:30 | B | 130 | 120 | NO | LO | 1 | 43 | TR | 0 | none |
| Torsvik | 980 | Unidentified seal | Y | 1 | 15-Sep | 21:39 | C | 200 | 190 | NO | LO | 1 | 43 | TR | 0 | none |
| Torsvik | 981 | Unidentified seal | Y | 1 | 15-Sep | 21:40 | C | 150 | 150 | NO | LO | 1 | 43 | TR | 0 | none |
| Torsvik | 982 | Unidentified seal | Y | 1 | 15-Sep | 21:42 | C | 50 | 50 | NO | LO | 1 | 43 | TR | 0 | none |
| Torsvik | 983 | Unidentified seal | Y | 1 | 15-Sep | 21:52 | C | 100 | 50 | NO | FS | 1 | 43 | TR | 0 | none |
| Torsvik | 984 | Unidentified seal | Y | 1 | 15-Sep | 22:10 | C | 200 | 190 | SA | SW | 1 | 41 | TR | 0 | none |
| Torsvik | 985 | Pacific walrus | Y | 1 | 15-Sep | 22:18 | C | 500 | 200 | SA | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 986 | Bearded seal | Y | 1 | 15-Sep | 22:43 | C | 70 | 50 | SP | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 987 | Bearded seal | Y | 1 | 15-Sep | 22:58 | C | 400 | 200 | SA | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 988 | Ringed seal | Y | 1 | 15-Sep | 23:47 | C | 80 | 60 | SA | LO | 1 | 41 | TR | 0 | none |
| Torsvik | 989 | Unidentified seal | Y | 1 | 15-Sep | 23:50 | C | 100 | 100 | NO | LO | 1 | 41 | TR | 0 | none |
| Torsvik | 990 | Ringed seal | Y | 1 | 15-Sep | 23:56 | C | 75 | 65 | SA | LO | 1 | 41 | TR | 0 | none |
| Torsvik | 991 | Bearded seal | Y | 1 | 15-Sep | 23:59 | C | 70 | 40 | SP | LO | 1 | 41 | TR | 0 | none |
| Torsvik | 992 | Bearded seal | Y | 1 | 16-Sep | 0:12 | C | 95 | 95 | SP | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 993 | Unidentified seal | Y | 1 | 16-Sep | 0:15 | C | 300 | 300 | SA | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 994 | Bearded seal | Y | 1 | 16-Sep | 0:15 | C | 140 | 140 | SP | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 999 | Pacific walrus | Y | 1 | 16-Sep | 0:16 | C | 30 | 30 | SA | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 995 | Unidentified seal | Y | 1 | 16-Sep | 0:19 | C | 100 | 90 | NO | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 996 | Pacific walrus | Y | 1 | 16-Sep | 0:20 | C | 50 | 30 | MI | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 997 | Pacific walrus | Y | 1 | 16-Sep | 0:22 | C | 80 | 80 | SP | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 998 | Bearded seal | Y | 1 | 16-Sep | 0:24 | C | 80 | 50 | SP | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 1000 | Unidentified seal | Y | 1 | 16-Sep | 0:33 | C | 120 |  |  |  | 1 | 42 | TR | 0 | none |
| Torsvik | 1001 | Unidentified seal | Y | 1 | 16-Sep | 0:36 | C | 100 | 100 | SA | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 1002 | Unidentified seal | Y | 1 | 16-Sep | 0:36 | C | 500 | 500 | NO | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 1003 | Ringed seal | Y | 1 | 16-Sep | 0:39 | C | 100 | 80 | PE | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 1004 | Pacific walrus | Y | 2 | 16-Sep | 0:42 | C | 300 | 100 | SA | LO | 1 | 42 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 1005 | Pacific walrus | Y | 1 | 16-Sep | 0:47 | C | 200 | 80 | SA | LO | 1 | 42 | TR | 0 | none |
| Torsvik | 1006 | Unidentified seal | Y | 1 | 16-Sep | 0:51 | C | 150 | 150 | SP | LO | 1 | 40 | TR | 0 | none |
| Torsvik | 1007 | Ringed seal | Y | 1 | 16-Sep | 0:55 | C | 110 | 90 | ST | LO | 1 | 43 | TR | 0 | none |
| Torsvik | 1008 | Ringed seal | Y | 1 | 16-Sep | 0:58 | C | 150 | | PE | LO | 1 | 43 | TR | 0 | none |
| Torsvik | 1009 | Ringed seal | Y | 1 | 16-Sep | 1:03 | C | 80 | 50 | SP | LO | 1 | 43 | TR | 0 | none |
| Torsvik | 1010 | Unidentified seal | Y | 1 | 16-Sep | 1:06 | C | 200 | 200 | SA | SW | 1 | 44 | TR | 0 | none |
| Torsvik | 1011 | Bearded seal | N | 1 | 16-Sep | 1:07 | C | 400 | 200 | SP | SW | 0 | 42 | TR | 0 | none |
| Torsvik | 1012 | Bearded seal | N | 1 | 16-Sep | 1:09 | C | 50 | 50 | SA | SW | 0 | 44 | TR | 0 | none |
| Torsvik | 1013 | Ringed seal | N | 1 | 16-Sep | 1:15 | C | 200 | 60 | PE | SW | 0 | 44 | TR | 0 | none |
| Torsvik | 1014 | Ringed seal | N | 1 | 16-Sep | 1:28 | C | 60 | 50 | ST | SA | 0 | 45 | TR | 0 | none |
| Torsvik | 1015 | Ringed seal | N | 1 | 16-Sep | 1:42 | C | 70 | 70 | SA | SW | 0 | 45 | TR | 0 | none |
| Torsvik | 1016 | Unidentified seal | N | 1 | 16-Sep | 1:48 | C | 500 | 500 | SP | SW | 0 | 45 | TR | 0 | none |
| Torsvik | 1017 | Ringed seal | N | 1 | 16-Sep | 1:56 | C | 150 | 40 | MI | LG | 0 | 46 | TR | 0 | none |
| Torsvik | 1018 | Ringed seal | N | 1 | 16-Sep | 2:05 | C | 60 | 30 | MI | LG | 1 | 46 | TR | 0 | none |
| Torsvik | 1019 | Ringed seal | N | 1 | 16-Sep | 2:13 | C | 120 | 80 | SA | LO | 1 | 46 | TR | 0 | none |
| Torsvik | 1020 | Bearded seal | N | 1 | 16-Sep | 2:16 | C | 60 | 20 | SA | SW | 1 | 45 | TR | 0 | none |
| Torsvik | 1021 | Pacific walrus | N | 2 | 16-Sep | 2:19 | C | 200 | 200 | MI | LO | 1 | 46 | TR | 0 | none |
| Torsvik | 1022 | Ringed seal | N | 1 | 16-Sep | 2:23 | C | 40 | 40 | SA | LO | 1 | 46 | TR | 0 | none |
| Torsvik | 1023 | Ringed seal | N | 1 | 16-Sep | 2:26 | C | 70 | 60 | SA | SW | 1 | 46 | TR | 0 | none |
| Torsvik | 1024 | Ringed seal | N | 1 | 16-Sep | 2:35 | C | 60 | 50 | ST | LO | 1 | 48 | TR | 0 | none |
| Torsvik | 1025 | Bearded seal | N | 1 | 16-Sep | 2:38 | C | 200 | 200 | SP | SW | 1 | 46 | TR | 0 | none |
| Torsvik | 1026 | Bearded seal | N | 1 | 16-Sep | 2:42 | C | 150 | 130 | NO | LO | 1 | 46 | TR | 0 | none |
| Torsvik | 1027 | Bearded seal | N | 1 | 16-Sep | 2:48 | C | 60 | 20 | NO | LO | 1 | 46 | TR | 0 | none |
| Torsvik | 1028 | Pacific walrus | N | 2 | 16-Sep | 2:55 | C | 80 | 80 | SA | SW | 1 | 46 | TR | 0 | none |
| Torsvik | 1029 | Unidentified seal | Y | 1 | 16-Sep | 3:38 | C | 10 | 10 | FL | FS | 2 | 46 | TR | 0 | none |
| Torsvik | 1030 | Pacific walrus | Y | 1 | 16-Sep | 3:56 | C | 100 | 100 | SA | DI | 2 | 47 | TR | 0 | none |
| Torsvik | 1031 | Pacific walrus | Y | 2 | 16-Sep | 3:56 | C | 100 | 10 | MI | LO | 2 | 47 | TR | 0 | none |
| Torsvik | 1032 | Pacific walrus | Y | 3 | 16-Sep | 4:03 | C | 250 | 240 | PE | LO | 1 | 47 | TR | 0 | none |
| Torsvik | 1033 | Pacific walrus | Y | 4 | 16-Sep | 4:09 | C | 200 | 80 | SA | LO | 1 | 47 | TR | 0 | none |
| Torsvik | 1034 | Ringed seal | Y | 1 | 16-Sep | 4:12 | C | 150 | 150 | NO | LO | 1 | 47 | TR | 0 | none |
| Torsvik | 1035 | Unidentified seal | Y | 1 | 16-Sep | 4:15 | C | 60 | 60 | NO | LO | 1 | 46 | TR | 0 | none |
| Torsvik | 1036 | Ringed seal | Y | 1 | 16-Sep | 4:21 | C | 60 | 50 | NO | LO | 1 | 47 | TR | 0 | none |
| Torsvik | 1037 | Unidentified seal | Y | 1 | 16-Sep | 4:23 | C | 100 | 60 | NO | LO | 1 | 45 | TR | 0 | none |
| Torsvik | 1038 | Pacific walrus | Y | 1 | 16-Sep | 4:36 | C | 60 | 60 | SA | SW | 2 | 46 | TR | 0 | none |
| Torsvik | 1039 | Pacific walrus | Y | 1 | 16-Sep | 4:45 | C | 200 | 150 | SP | SW | 2 | 47 | TR | 0 | none |
| Torsvik | 1040 | Ringed seal | Y | 1 | 16-Sep | 4:48 | C | 20 | 10 | SA | LO | 2 | 47 | TR | 0 | none |
| Torsvik | 1041 | Pacific walrus | Y | 1 | 16-Sep | 4:51 | C | 200 | 200 | SA | SW | 2 | 47 | TR | 0 | none |
| Torsvik | 1042 | Spotted seal | Y | 1 | 16-Sep | 5:28 | C | 40 | 40 | PE | SW | 2 | 50 | TR | 0 | none |
| Torsvik | 1043 | Gray whale | Y | 1 | 16-Sep | 23:44 | C | 100 | 100 | SA | SW | 2 | 24 | TR | 0 | none |
| Torsvik | 1044 | Unidentified seal | N | 1 | 17-Sep | 0:38 | C | 10 | 10 | FL | FS | 2 | 32 | TR | 0 | none |
| Torsvik | 1045 | Gray whale | Y | 12 | 17-Sep | 2:18 | C | 1966 | 50 | MI | FG | 2 | 39 | TR | 0 | none |
| Torsvik | 1046 | Unidentified seal | N | 1 | 17-Sep | 20:04 | B | 30 | 30 | NO | LO | 4 | 42 | TR | 0 | none |
| Torsvik | 1047 | Unidentified seal | N | 1 | 17-Sep | 20:06 | B | 10 | 10 | NO | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 1048 | Unidentified seal | N | 1 | 17-Sep | 20:22 | B | 10 | 10 | NO | LO | 4 | 43 | TR | 0 | none |
| Torsvik | 1049 | Ribbon seal | N | 1 | 17-Sep | 20:50 | B | 20 | 10 | NO | LO | 5 | 43 | TR | 0 | none |
| Torsvik | 1050 | Unidentified seal | N | 1 | 17-Sep | 21:13 | B | 5 | 5 | SP | SW | 5 | 45 | TR | 0 | none |
| Torsvik | 1051 | Unidentified seal | Y | 1 | 18-Sep | 1:05 | B | 100 | 100 | NO | LO | 5 | 45 | TR | 0 | none |
| Torsvik | 1052 | Unidentified seal | Y | 1 | 18-Sep | 3:19 | B | 50 | 50 | NO | LO | 4 | 41 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 1053 | Unidentified seal | Y | 1 | 18-Sep | 3:21 | B | 15 | 15 | NO | LO | 4 | 41 | TR | 0 | none |
| Torsvik | 1054 | Ringed seal | N | 1 | 18-Sep | 4:14 | B | 5 | 5 | NO | LO | 4 | 42 | TR | 0 | none |
| Torsvik | 1055 | Ringed seal | N | 1 | 18-Sep | 23:00 | B | 20 | 10 | MI | LO | 1 | 38 | OT | 0 | none |
| Gulf Provider | 281a | Unidentified whale | Y | 1 | 19-Sep | 18:38 | B | 100 | 100 | SP | DI | 4 | 44.242 | TR | 0 | none |
| Gulf Provider | 282a | Pacific walrus | Y | 4 | 21-Sep | 18:12 | B | 600 | 400 | SP | SI | 2 | 43.939 | TR | 0 | none |
| Gulf Provider | 283a | Pacific walrus | Y | 1 | 21-Sep | 18:49 | B | 500 | 400 | SP | SI | 2 | 43.939 | TR | 0 | none |
| Gulf Provider | 284a | Unidentified seal | N | 1 | 21-Sep | 19:34 | B | 300 | 300 | MI | SI | 2 | 43.636 | TR | 0 | none |
| Gulf Provider | 285a | Spotted seal | Y | 1 | 21-Sep | 23:30 | B | 460 | 460 | SA | SI | 2 | 41.515 | TR | 0 | none |
| Gulf Provider | 286a | Bearded seal | Y | 1 | 23-Sep | 3:29 | B | 500 | 200 | SA | DI | 2 | 48.182 | TR | 0 | none |
| Gulf Provider | 287a | Pacific walrus | Y | 3 | 23-Sep | 4:17 | B | 100 | 150 | SA | DI | 2 | 48.182 | TR | 0 | none |
| Gulf Provider | 288a | Spotted seal | N | 1 | 24-Sep | 0:30 | B | 100 |  | SP | SI | 1 | 45.758 | TR | 0 | none |
| Gulf Provider | 289a | Pacific walrus | Y | 2 | 24-Sep | 1:14 | B | 1850 | 1850 | SP | SI | 1 | 43.939 | TR | 0 | none |
| Gulf Provider | 290a | Unidentified seal | Y | 1 | 24-Sep | 1:28 | B | 600 | 600 | SP | SI | 1 | 44.242 | TR | 0 | none |
| Gulf Provider | 291a | Pacific walrus | Y | 2 | 24-Sep | 1:41 | B | 500 | 500 | SP | SW | 1 | 44.545 | TR | 0 | none |
| Gulf Provider | 292a | Bearded seal | Y | 1 | 24-Sep | 2:18 | B | 500 | 500 | SA | SW | 1 | 45.152 | TR | 0 | none |
| Gulf Provider | 293a | Bearded seal | Y | 1 | 24-Sep | 2:25 | B | 500 | 500 | SA | SW | 1 | 45.152 | TR | 0 | none |
| Gulf Provider | 294a | Spotted seal | Y | 1 | 24-Sep | 2:26 | B | 400 | 400 | SP | SI | 1 | 45.152 | TR | 0 | none |
| Gulf Provider | 295a | Spotted seal | Y | 1 | 24-Sep | 2:27 | B | 500 | 500 | SP | SW | 1 | 45.152 | TR | 0 | none |
| Gulf Provider | 296a | Spotted seal | Y | 1 | 24-Sep | 2:40 | B | 300 | 200 | SA | TH | 1 | 45.152 | TR | 0 | none |
| Gulf Provider | 297a | Spotted seal | Y | 1 | 24-Sep | 2:43 | B | 50 | 50 | SA | TH | 1 | 44.848 | TR | 0 | none |
| Gulf Provider | 298a | Bearded seal | Y | 1 | 24-Sep | 2:50 | B | 100 | 100 | SA | SW | 1 | 44.848 | TR | 0 | none |
| Gulf Provider | 299a | Spotted seal | Y | 1 | 24-Sep | 2:51 | B | 200 | 200 | SA | SW | 1 | 44.848 | TR | 0 | none |
| Gulf Provider | 300a | Bearded seal | Y | 1 | 24-Sep | 4:14 | B | 300 | 300 | SA | SW | 1 | 43.333 | TR | 0 | none |
| Gulf Provider | 301a | Spotted seal | Y | 1 | 24-Sep | 4:17 | B | 100 | 100 | SA | SW | 1 | 43.03 | TR | 0 | none |
| Gulf Provider | 302a | Spotted seal | Y | 1 | 24-Sep | 4:39 | B | 100 | 100 | SA | TH | 1 | 42.727 | TR | 0 | none |
| Gulf Provider | 303a | Bearded seal | Y | 1 | 24-Sep | 4:44 | B | 100 | 100 | ST | SW | 1 | 42.424 | TR | 0 | none |
| Gulf Provider | 304a | Spotted seal | Y | 1 | 24-Sep | 5:13 | B | 400 | 400 | SA | SW | 1 | 41.515 | TR | 0 | none |
| Gulf Provider | 305a | Unidentified seal | Y | 1 | 24-Sep | 18:12 | B | 50 | 50 | SA | SI | 1 | 43.333 | TR | 0 | none |
| Gulf Provider | 306a | Spotted seal | Y | 1 | 24-Sep | 18:39 | B | 200 | 100 | SA | SW | 1 | 42.727 | TR | 0 | none |
| Gulf Provider | 307a | Spotted seal | Y | 1 | 24-Sep | 18:40 | B | 800 | 800 | SA | SW | 1 | 42.727 | TR | 0 | none |
| Gulf Provider | 308a | Spotted seal | Y | 1 | 24-Sep | 18:47 | B | 300 | 300 | SA | SW | 1 | 42.727 | TR | 0 | none |
| Gulf Provider | 309a | Bearded seal | Y | 1 | 24-Sep | 19:40 | B | 75 | 75 | SA | SI | 0 | 42.424 | TR | 0 | none |
| Gulf Provider | 310a | Spotted seal | Y | 1 | 24-Sep | 19:44 | B | 20 | 20 | SP | SI | 0 | 42.424 | TR | 0 | none |
| Gulf Provider | 311a | Unidentified seal | Y | 1 | 24-Sep | 20:25 | B | 800 | 800 | SA | SI | 0 | 41.818 | TR | 0 | none |
| Gulf Provider | 312a | Spotted seal | Y | 1 | 24-Sep | 20:46 | B | 100 | 100 | SA | SW | 1 | 41.515 | TR | 0 | none |
| Gulf Provider | 313a | Unidentified seal | Y | 1 | 24-Sep | 21:05 | B | 400 | 400 | SA | SW | 1 | 42.121 | TR | 0 | none |
| Gulf Provider | 314a | Pacific walrus | Y | 1 | 24-Sep | 23:19 | B | 300 | 300 | SA | SW | 1 | 41.515 | TR | 0 | none |
| Gulf Provider | 315a | Pacific walrus | Y | 3 | 25-Sep | 2:52 | B | 800 | 800 | SA | SW | 1 | 44.545 | TR | 0 | none |
| Gulf Provider | 316a | Spotted seal | Y | 1 | 25-Sep | 3:25 | B | 200 | 200 | SA | SW | 1 | 44.545 | TR | 0 | none |
| Gulf Provider | 317a | Bearded seal | Y | 1 | 25-Sep | 4:17 | B | 200 | 200 | SA | SW | 1 | 45.152 | TR | 0 | none |
| Gulf Provider | 318a | Spotted seal | Y | 1 | 25-Sep | 19:34 | B | 100 | 100 | SA | SI | 3 | 45.152 | TR | 0 | none |
| Gulf Provider | 319a | Beluga whale | N | 1 | 25-Sep | 20:39 | B | 50 | 50 | DE | OT | 2 | 44.242 | TR | 0 | none |
| Torsvik | 1464 | Ringed seal | Y | 1 | 28-Sep | 22:52 | B | 40 | 30 | NO | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 1465 | Ringed seal | Y | 1 | 29-Sep | 3:17 | B | 100 | 75 | ST | LO | 4 | 44 | TR | 0 | none |
| Torsvik | 1466 | Ringed seal | Y | 1 | 29-Sep | 16:54 | B | 125 | 75 | MI | LO | 1 | 44 | TR | 0 | none |
| Torsvik | 1467 | Bearded seal | Y | 1 | 29-Sep | 17:21 | B | 150 | 150 | UN | FD | 0 | 44 | TR | 0 | none |
| Torsvik | 1468 | Ringed seal | Y | 1 | 29-Sep | 17:27 | B | 250 | 250 | ST | SW | 0 | 44 | TR | 0 | none |
| Torsvik | 1469 | Unidentified seal | Y | 1 | 29-Sep | 17:36 | B | 175 | 175 | SA | SW | 1 | 44 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 1470 | Unidentified seal | Y | 1 | 29-Sep | 17:40 | B | 200 | 200 | UN | FD | 1 | 44 | TR | 0 | none |
| Torsvik | 1471 | Unidentified seal | Y | 1 | 29-Sep | 17:46 | B | 40 | 40 | NO | LO | 1 | 44 | TR | 0 | none |
| Torsvik | 1472 | Unidentified seal | Y | 1 | 29-Sep | 17:46 | B | 350 | 350 | UN | SW | 1 | 44 | TR | 0 | none |
| Torsvik | 1473 | Unidentified seal | Y | 1 | 29-Sep | 17:52 | B | 450 | 200 | SP | SW | 1 | 44 | TR | 0 | none |
| Torsvik | 1474 | Pacific walrus | Y | 1 | 29-Sep | 18:38 | B | 100 | 30 | MI | SW | 0 | 44 | TR | 0 | none |
| Torsvik | 1475 | Bearded seal | Y | 1 | 29-Sep | 18:44 | B | 150 | 150 | SA | SW | 0 | 44 | TR | 0 | none |
| Torsvik | 1476 | Ringed seal | Y | 1 | 29-Sep | 18:50 | B | 80 | 30 | ST | SW | 0 | 44 | TR | 0 | none |
| Torsvik | 1477 | Ringed seal | Y | 1 | 29-Sep | 18:51 | B | 100 | 50 | ST | SW | 0 | 44 | TR | 0 | none |
| Torsvik | 1478 | Unidentified seal | Y | 1 | 29-Sep | 19:01 | B | 100 | 80 | ST | SW | 0 | 45 | TR | 0 | none |
| Torsvik | 1479 | Ringed seal | Y | 1 | 29-Sep | 19:04 | B | 60 | 30 | NO | LO | 0 | 45 | TR | 0 | none |
| Torsvik | 1480 | Ringed seal | Y | 2 | 29-Sep | 19:20 | B | 80 | 60 | NO | LO | 1 | 45 | TR | 0 | none |
| Torsvik | 1481 | Unidentified seal | Y | 1 | 29-Sep | 19:30 | B | 300 | 300 | SA | SW | 1 | 45 | TR | 0 | none |
| Torsvik | 1482 | Unidentified seal | Y | 1 | 29-Sep | 19:36 | B | 400 | 400 | NO | LO | 1 | 45 | TR | 0 | none |
| Torsvik | 1483 | Ringed seal | Y | 1 | 29-Sep | 19:44 | B | 100 | 100 | SP | SW | 1 | 45 | TR | 0 | none |
| Torsvik | 1484 | Bearded seal | Y | 1 | 29-Sep | 20:00 | B | 400 | 200 | UN | SW | 1 | 45 | TR | 0 | none |
| Torsvik | 1485 | Ringed seal | Y | 1 | 29-Sep | 20:04 | B | 100 | 100 | SA | SW | 1 | 45 | TR | 0 | none |
| Torsvik | 1486 | Bearded seal | Y | 1 | 29-Sep | 20:04 | B | 750 | 200 | PE | SW | 1 | 45 | TR | 0 | none |
| Torsvik | 1487 | Ringed seal | Y | 1 | 29-Sep | 20:40 | B | 125 | 100 | NO | RA | 1 | 45 | TR | 0 | none |
| Torsvik | 1488 | Ringed seal | Y | 1 | 29-Sep | 20:47 | B | 250 | 125 | SA | LO | 1 | 45 | TR | 0 | none |
| Torsvik | 1489 | Bearded seal | Y | 1 | 29-Sep | 21:55 | B | 100 | 75 | SA | SW | 1 | 45 | TR | 0 | none |
| Torsvik | 1490 | Unidentified seal | Y | 1 | 29-Sep | 22:01 | B | 400 | 100 | UN | SW | 1 | 45 | TR | 0 | none |
| Torsvik | 1491 | Ringed seal | Y | 1 | 29-Sep | 22:16 | B | 200 | 200 | SP | SW | 1 | 44 | TR | 0 | none |
| Torsvik | 1492 | Bearded seal | Y | 1 | 29-Sep | 22:16 | B | 80 | 80 | SA | SW | 1 | 44 | TR | 0 | none |
| Torsvik | 1493 | Unidentified seal | Y | 1 | 29-Sep | 22:55 | B | 200 | 200 | MI | SW | 0 | 44 | TR | 0 | none |
| Torsvik | 1494 | Ringed seal | Y | 1 | 29-Sep | 23:05 | B | 120 | 80 | ST | SW | 0 | 44 | TR | 0 | none |
| Torsvik | 1495 | Ringed seal | N | 1 | 29-Sep | 23:16 | B | 100 | 60 | SP | SW | 0 | 44 | TR | 0 | none |
| Torsvik | 1496 | Ringed seal | N | 1 | 29-Sep | 23:18 | B | 60 | 60 | MI | LO | 0 | 44 | TR | 0 | none |
| Torsvik | 1497 | Ringed seal | Y | 1 | 30-Sep | 0:12 | B | 80 | 80 | SA | SW | 1 | 43 | TR | 0 | none |
| Torsvik | 1498 | Ringed seal | Y | 1 | 30-Sep | 0:32 | B | 30 | 10 | UN | LO | 0 | 43 | TR | 0 | none |
| Torsvik | 1499 | Ringed seal | Y | 1 | 30-Sep | 18:46 | B | 125 | 125 | NO | LO | 2 | 42 | TR | 0 | none |
| Torsvik | 1500 | Ringed seal | Y | 1 | 30-Sep | 18:55 | B | 80 | 80 | SA | SW | 2 | 42 | TR | 0 | none |
| Torsvik | 1501 | Ringed seal | Y | 1 | 30-Sep | 19:22 | B | 50 | 50 | NO | LO | 2 | 42 | TR | 0 | none |
| Torsvik | 1502 | Ringed seal | Y | 1 | 30-Sep | 21:24 | B | 80 | 60 | SP | LO | 2 | 43 | TR | 0 | none |
| Torsvik | 1503 | Ringed seal | Y | 1 | 30-Sep | 22:31 | B | 120 | 100 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 1504 | Ringed seal | Y | 1 | 30-Sep | 22:45 | B | 100 | 100 | NO | LO | 2 | 44 | TR | 0 | none |
| Torsvik | 1505 | Unidentified seal | Y | 1 | 1-Oct | 22:28 | B | 40 | 40 | UN | TH | 2 | 45 | TR | 0 | none |
| Torsvik | 1506 | Unidentified seal | Y | 1 | 1-Oct | 22:33 | B | 150 | 150 | NO | LO | 2 | 46 | TR | 0 | none |
| Torsvik | 1507 | Unidentified seal | Y | 1 | 1-Oct | 23:02 | B | 50 | 50 | UN | DI | 2 | 44 | TR | 0 | none |
| Torsvik | 1508 | Ringed seal | Y | 1 | 1-Oct | 23:21 | B | 200 | 100 | SP | SW | 2 | 44 | TR | 0 | none |
| Torsvik | 1509 | Ringed seal | Y | 1 | 1-Oct | 23:32 | B | 50 | 10 | ST | SW | 2 | 43 | TR | 0 | none |
| Torsvik | 1510 | Ringed seal | Y | 1 | 1-Oct | 23:41 | B | 20 | 10 | SP | SW | 2 | 43 | TR | 0 | none |
| Torsvik | 1511 | Ringed seal | Y | 1 | 1-Oct | 23:46 | B | 80 | 80 | MI | LO | 2 | 42 | TR | 0 | none |
| Torsvik | 1512 | Unidentified seal | Y | 1 | 2-Oct | 0:33 | B | 200 | 200 | SP | SW | 2 | 41 | TR | 0 | none |
| Torsvik | 1513 | Unidentified seal | Y | 1 | 2-Oct | 0:45 | B | 30 | 30 | MI | DI | 2 | 41 | TR | 0 | none |
| Torsvik | 1514 | Unidentified seal | Y | 1 | 2-Oct | 0:53 | B | 100 | 100 | NO | LO | 2 | 41 | TR | 0 | none |
| Torsvik | 1515 | Unidentified seal | Y | 1 | 2-Oct | 1:05 | B | 75 | 75 | SA | SW | 2 | 42 | TR | 0 | none |
| Torsvik | 1516 | Unidentified seal | Y | 1 | 2-Oct | 1:28 | B | 60 | 60 | UN | DI | 2 | 43 | TR | 0 | none |
| Torsvik | 1517 | Ringed seal | Y | 1 | 2-Oct | 1:38 | B | 80 | 20 | ST | RA | 2 | 43 | TR | 0 | none |

TABLE G.4. Continued.

| Vessel | Sighting ID | Species | Useable (Y) or Non-useable (N)[a] | Group Size | Day in 2006 | Time (GMT) | Location[a] | Initial Sighting Distance (m) from observer | CPA[b] (m) | Initial Move-ment[c] | Initial Behav.[d] | Bf[e] | Water Depth (m)[f] | Vessel Activ.[g] | Airguns Vol. ($in^3$)[h] | Mitig. (SZ, PZ, None)[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Torsvik | 1518 | Ringed seal | Y | 1 | 2-Oct | 1:40 | B | 100 | 100 | NO | LO | 2 | 43 | TR | 0 | none |
| Torsvik | 1519 | Ringed seal | Y | 1 | 2-Oct | 1:41 | B | 200 | 60 | SA | LO | 2 | 43 | TR | 0 | none |
| Torsvik | 1520 | Pacific walrus | Y | 2 | 2-Oct | 1:50 | C | 150 | 30 | SA | LO | 2 | 43 | TR | 0 | none |
| Torsvik | 1521 | Ringed seal | Y | 1 | 2-Oct | 1:58 | C | 80 | 40 | SA | SW | 2 | 43 | TR | 0 | none |
| Torsvik | 1522 | Unidentified seal | Y | 1 | 2-Oct | 2:05 | C | 10 | 10 | MI | TH | 2 | 43 | TR | 0 | none |
| Torsvik | 1523 | Unidentified seal | Y | 1 | 2-Oct | 2:45 | C | 80 | 20 | SA | TH | 3 | 44 | TR | 0 | none |
| Torsvik | 1524 | Ringed seal | Y | 1 | 2-Oct | 2:45 | C | 125 | 75 | SA | TH | 3 | 44 | TR | 0 | none |
| Torsvik | 1525 | Unidentified seal | Y | 1 | 2-Oct | 3:33 | C | 20 | 20 | MI | SI | 2 | 44 | TR | 0 | none |
| Torsvik | 1526 | Unidentified seal | Y | 1 | 2-Oct | 3:36 | C | 5 | 5 | NO | TH | 2 | 44 | TR | 0 | none |
| Torsvik | 1527 | Ringed seal | Y | 1 | 2-Oct | 3:41 | C | 80 | 50 | SA | SW | 2 | 44 | TR | 0 | none |
| Torsvik | 1528 | Bearded seal | Y | 1 | 2-Oct | 4:08 | C | 80 | 30 | SP | SW | 2 | 44 | TR | 0 | none |
| Torsvik | 1593 | Unidentified seal | Y | 1 | 4-Oct | 18:19 | B | 60 | 60 | SP | SW | 6 | 53 | TR | 0 | none |
| Torsvik | 1594 | Ringed seal | Y | 1 | 4-Oct | 19:31 | B | 100 | 75 | PE | SW | 6 | 51 | TR | 0 | none |
| Torsvik | 1595 | Ringed seal | N | 1 | 4-Oct | 21:13 | B | 20 | 20 | SA | SW | 5 | 42 | TR | 0 | none |
| Torsvik | 1596 | Ringed seal | Y | 1 | 6-Oct | 23:59 | B | 30 | 30 | SA | SW | 4 | 42 | TR | 0 | none |
| Torsvik | 1597 | Bearded seal | Y | 1 | 8-Oct | 21:10 | B | 100 | 60 | NO | RE | 5 | 36 | TR | 0 | none |
| Torsvik | 1598 | Ringed seal | Y | 1 | 8-Oct | 23:43 | B | 150 | 150 | NO | LO | 5 | 40 | TR | 0 | none |
| Torsvik | 1599 | Harbor porpoise | N | 2 | 9-Oct | 0:33 | B | 60 | 60 | SP | SW | 5 | 46 | TR | 0 | none |
| Torsvik | 1600 | Ringed seal | Y | 1 | 9-Oct | 1:38 | B | 150 | 125 | NO | LO | 5 | 45 | TR | 0 | none |
| Torsvik | 1601 | Ringed seal | Y | 1 | 9-Oct | 1:56 | B | 80 | 50 | MI | LO | 6 | 46 | TR | 0 | none |
| Torsvik | 1602 | Harbor porpoise | N | 2 | 9-Oct | 18:06 | B | 60 | 25 | SP | SW | 4 | 56 | TR | 0 | none |
| Gulf Provider | 439a | Spotted seal | Y | 1 | 10-Oct | 21:04 | B | 75 | | ST | SW | 5 | 129 | TR | 0 | none |
| Gulf Provider | 440a | Spotted seal | Y | 1 | 10-Oct | 21:39 | B | 100 | | NO | LO | 4 | 134 | TR | 0 | none |
| Gulf Provider | 441a | Bowhead whale | Y | 1 | 10-Oct | 21:58 | B | 1011 | 600 | SP | SW | 4 | 140 | TR | 0 | none |
| Gulf Provider | 442a | Bowhead whale | Y | 3 | 10-Oct | 22:30 | C | 1000 | 1000 | SP | FD | 4 | 140 | TR | 0 | none |
| Gulf Provider | 443a | Bowhead whale | Y | 1 | 10-Oct | 22:37 | C | 900 | 800 | SP | BL | 4 | 137 | TR | 0 | none |
| Gulf Provider | 444a | Bowhead whale | Y | 1 | 10-Oct | 22:49 | C | 1011 | | SP | BL | 4 | 143 | TR | 0 | none |
| Gulf Provider | 445a | Bowhead whale | Y | 2 | 10-Oct | 22:51 | C | 600 | | SP | BL | 4 | 141 | TR | 0 | none |
| Gulf Provider | 446a | Bowhead whale | Y | 1 | 10-Oct | 22:56 | C | 1397 | | SP | BL | 4 | 142 | TR | 0 | none |
| Gulf Provider | 447a | Bowhead whale | Y | 1 | 10-Oct | 23:25 | C | 1000 | | SP | BL | 4 | 141 | TR | 0 | none |
| Gulf Provider | 448a | Bowhead whale | Y | 1 | 11-Oct | 0:33 | C | 1000 | | SP | BL | 4 | 144 | TR | 0 | none |
| Gulf Provider | 449a | Bowhead whale | Y | 1 | 11-Oct | 1:03 | C | 300 | | PE | BL | 4 | 141 | TR | 0 | none |
| Gulf Provider | 450a | Pacific walrus | Y | 1 | 11-Oct | 2:19 | C | 300 | | NO | LO | 5 | 134 | TR | 0 | none |
| Gulf Provider | 451a | Bowhead whale | Y | 1 | 11-Oct | 19:30 | C | 400 | 400 | SP | FD | 3 | 143 | TR | 0 | none |
| Gulf Provider | 452a | Spotted seal | Y | 1 | 11-Oct | 21:06 | C | 50 | | NO | LO | 3 | 141 | TR | 0 | none |
| Gulf Provider | 453a | Spotted seal | N | 1 | 11-Oct | 21:45 | C | 5 | | ST | LO | 3 | 144 | TR | 0 | none |
| Gulf Provider | 454a | Spotted seal | Y | 1 | 11-Oct | 22:33 | C | 200 | 200 | SP | LG | 3 | 139 | TR | 0 | none |
| Gulf Provider | 455a | Ringed seal | N | 1 | 12-Oct | 0:39 | C | 200 | | ST | SW | 4 | 141 | TR | 0 | none |
| Gulf Provider | 456a | Spotted seal | N | 1 | 12-Oct | 1:30 | C | 100 | 100 | SA | FD | 4 | 143 | TR | 0 | none |

[a] Useable or non-useable sightings: Y= useable sightings made during useable daylight periods of visual observation, as defined in *List of Acronyms and Abbreviations,* N= non-useable sightings.
[b] Refers to generalized locations shown in Figure G.1.
[c] Closest point of approach: chase vessel sightings have closest point of approach to airguns.

[d] Initial movement of the animal(s) relative to the vessel: MI=milling, FL=Flee, PE=swimming perpendicular to ship or across bow, SA=swimming away, SP=swimming parallel, ST=swimming toward, NO=no movement, UN=unknown.
[e] Initial behavior observed: BR=breach, FL=fluke, DI=dive, FD=forward dive, SW=swim, TR=travel, ST=surface-active travel, LG=log, RE=rest, LO=look, SI=sink, TH=thrash, FE/FG=feed, MI=mill, SA=surface-active, UN=unknown.
[f] Beaufort Wind Force Scale.
[g] Activity of the vessel at the time of the sighting: TR=travelling within the study area, OT=other, DP=deploying equipment.
[h] Combined volume of operating airguns at the time of the sighting.
[i] Mitigation measure taken: SZ=safety zone shut-down, PZ=safety zone power-down, None=no measure taken.

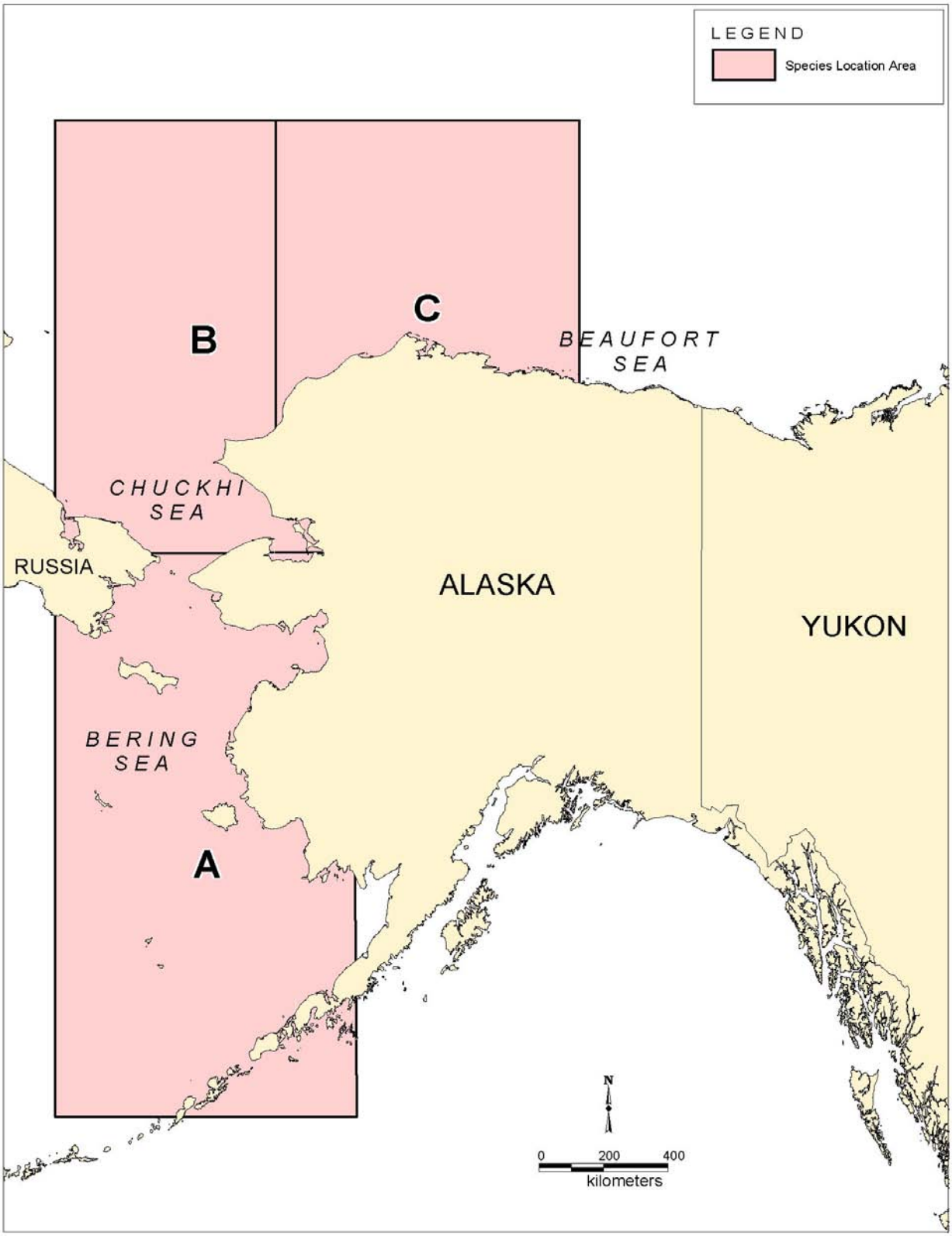



FIGURE G.1. Location areas off Alaska where marine mammals were sighted from the *Patriot* and *Chase Vessel.* Please refer to Table G.3 for further details on these sightings.

# APPENDIX H:
## SIGHTINGS WITH POWER DOWNS AND SHUT DOWNS DURING THE CHUKCHI SEA SEISMIC SURVEY

- **Sighting #13**: On July 24 at 21:48 GMT, there was a power down for a single bowhead whale. It was first sighted blowing at 21:43 GMT, ahead of the vessel about 756 m from the observer. The whale then resurfaced just 524 m ahead of the MMO at 21:45 GMT, prompting a power down of the full array. Unfortunately, due to some confusion, the power down did not occur for another 3 min. Since the bowhead whale approached the 16 operating airguns within 824 m while underwater, within the 180 dB rms sound level distance of 1112 m, it was ***likely*** exposed to ≥180 dB rms.

- **Sighting #30**: The only shut down of the cruise occurred for an unidentified seal on July 26 at 06:00 GMT. The seal surfaced directly behind the vessel, ~30 m from the single operating mitigation airgun (well within the shut down safety radius of 145 m), and dove near the airgun before the shut down occurred. The seal was within the 190 dB rms distance of 62 m, so was ***very likely*** exposed to sounds ≥190 dB rms. The seal was re-sighted at 06:10 GMT, 150 m from the array.

- **Sighting #36**: A power down was requested for a ringed seal at 16:16 GMT on July 26. The baby ringed seal surfaced very close to the starboard side of the vessel, 303 m from the fully operating airgun array, within the power down radius of 500 m. The seal continued swimming toward the airguns and left the safety radius 11 min. after the power down occurred. Since the seal was observed surfacing within the 190 dB rms distance of 517 m, it was ***very likely*** exposed to ≥190 dB before it surfaced.

- **Sighting #39**: Another ringed seal prompted a power down on July 29 at 14:01 GMT. The ringed seal was sighted 150 m from the MMO, looking, diving, and resurfacing three times within the safety radius, staying 150 m in front of the vessel, or 397 m from the 16 airguns. It was ***likely*** exposed to ≥190 dB rms before the power down occurred.

- **Sighting #41**: A power down was requested at 18:03 GMT, July 29. An unidentified seal was sighted ahead, 150 m from the MMO, or 397 m to the 16 airgun array, within the 500 m safety radius. The animal was looking and diving within the 190 dB rms distance when the power down occurred. This seal was ***likely*** exposed to ≥190 dB rms.

- **Sighting #42**: A ringed seal was sighted within the 500 m safety radius, resulting in a power down at 03:12 GMT on July 30. It was sighted swimming 40 m from the MMO, ahead on the port side, looking then diving and re-surfacing a minute later 100 m away. A ramp up had just started 3 min before this sighting, so <16 airguns were operating. The ringed seal dove 322 m from the airguns, and the 190 dB rms distance was <517 m, but it was still ***likely*** exposed to ≥190 dB rms.

- **Sighting #43**: A bearded seal was sighted ahead on the port side, 84 m from the observer or 350 m to the 16 airguns, prompting a power down at 16:22 GMT on Aug. 1. The bearded seal surfaced with a splash, looked toward the vessel and swam away. It then stopped, looked around and then dove and disappeared. The sighting lasted about a minute and a half. Since the seal surfaced within the 190 dB rms distance of 517 m, it was ***very likely*** exposed to ≥190 dB rms while underwater.

- **Sighting #44**: A power down occurred on Aug. 3 at 00:53 GMT, for an unidentified seal within the 500 m safety radius. The seal was originally sighted at 00:49 GMT, thrashing directly ahead of the vessel, 25 m from the MMO and 325 m from the 16 firing airguns. It then re-surfaced about 4 min later, 100 m from the MMO, at which time the power down occurred. The seal dove well underwater within the 190 dB rms distance before the power down occurred, so was ***likely*** exposed to sounds ≥190 dB rms. Visibility was less than a kilometer at the time of the sighting.
- **Sighting #45**: There was a power down requested for an unidentified seal (possibly a ringed seal) on Aug. 3 at 01:14 GMT. The seal was sighted only once, ahead of the vessel, 50 m from the MMO, or 328 m from the airguns. The sighting occurred in reduced visibility (<1 km), during a ramp up sequence which had started 4 min earlier. Therefore <16 airguns were operating. The animal was sighted within the 190 dB rms distance of <517 m, so was still ***likely*** exposed to ≥190 dB rms before surfacing and after diving.
- **Sighting #46**: On Aug. 3 at 01:48 GMT, a power down occurred due to a ringed seal sighting within the 500 m safety radius. The ringed seal was first sighted swimming ahead on the port side of the vessel, 50 m from the MMO or 328 m to the airguns. It dove and resurfaced about 1 min later during the power down, 60 m away from the MMO and swimming toward the airguns. This sighting happened in bad visibility (<1 km), 18 min into a ramp up sequence, so close to 16 guns would have been firing. Given that the seal dove within the 190 dB rms distance before the power down, it is ***very likely*** that it received ≥190 dB rms.
- **Sighting #47**: A power down was requested for an unidentified seal at 08:58 GMT on Aug. 3. The seal was sighted ahead of the vessel, surfacing twice briefly, 100 m and then 50 m from the MMO. The visibility was severely reduced (<1 km) at this time. The power down occurred when the animal surfaced 344 m away from the full airgun array (within the 190 dB rms distance of 517 m), making it ***likely*** to have been exposed to ≥190 dB rms.
- **Sighting #48**: There was an unidentified seal sighted within the 500 m safety radius, prompting a power down on Aug. 3 at 12:40 GMT. The seal was sighted ahead on the port side of the vessel in reduced visibility (<1 km), 100 m away from the MMO or 360 m to the 16 operating airguns. The seal was initially sighted within the 190 dB rms distance, so was ***likely*** exposed to ≥190 dB rms before surfacing.
- **Sighting #50**: A power down occurred at 21:49 GMT on Aug. 3 for a Pacific walrus. The walrus was sighted 200 m ahead of the vessel, at which time the 16 guns were powered down. It continued swimming toward the vessel coming within 50 m of the bow, looking up and then continuing toward the stern of the vessel, approaching the remaining operational airgun within 150 m before continuing to swim away. The walrus was first sighted 484 m from the airguns, just within the 190 dB rms distance of 517 m, so was ***likely*** exposed to ≥190 dB rms.
- **Sighting #51**: On Aug. 4 at 07:02 GMT a power down was requested for an unidentified pinniped (possibly a Pacific walrus) within the 500 m safety zone. The unidentified pinniped was sighted ahead on the port side, 40 m from the MMO, with only a single splash seen. The 16 guns were immediately powered down to one gun. However, the animal was within 322 m of the fully operating array when it dove, making it ***very likely*** to have been exposed to sounds ≥190 dB rms.
- **Sighting #52**: A power down occurred for two Pacific walruses on Aug. 5 at 09:19 GMT. The mother and calf walrus were thrashing away from the vessel, off the port side just 14 m from the MMO. A power down from 16 guns was requested, and the MMO could not see the animals

leaving the safety radius due to bad fog. The two walruses were sighted 300 m from the airguns, within the 190 dB rms distance, so were ***likely*** exposed to ≥190 dB rms.

- **Sighting #53**: An unidentified seal within the 500 m safety radius prompted a power down at 00:46 GMT on Aug. 6. The seal was sighted ahead of the vessel on the port side, swimming 60 m from the MMO or 334 m to the 16 operating airguns. It may have been a bearded seal, but was not seen again in order to confirm. Since the animal was sighted within the 190 dB rms distance, it was ***likely*** exposed to ≥190 dB rms before surfacing.
- **Sighting #62**: There was a power down for a ringed seal on Aug. 16 at 20:22 GMT. The seal was first sighted at 20:20 GMT, swimming ahead and to starboard of the vessel, 200 m from the MMO. It appeared to be swimming away, but then dove and resurfaced closer, about 150 m from the observer or 335 m to the airguns, at which time a power down of the 16 airguns was requested. The ringed seal dove within the 190 dB rms distance of 517 m before the power down, so was ***very likely*** ensonified at ≥190 dB rms.
- **Sighting #68:** On Aug. 17 at 03:41 GMT, a power down occurred due to an unidentified seal sighting. The seal (possibly a ringed seal) was sighted ahead on the port side, 20 m from the observer or 310 m to the airguns, vigorously swimming away from the vessel and then diving. This sighting occurred 23 min into a ramp up sequence that typically last 21 min. It is therefore likely that the full 16 airguns were firing when the power down was requested. The seal dove within the 190 dB rms distance of 517 m, so was ***very likely*** exposed briefly to sounds ≥190 dB rms.
- **Sighting #72:** A power down was requested on Aug. 17 at 04:58 GMT. Three walruses (2 adults, one calf) surfaced 200 m ahead of the observer (483 m from the airguns) and appeared to be swimming away from the safety radius when they dove. They resurfaced 4 min later though, just 50 m ahead of bow or 436 m to the airguns and then dove again, at which time the power down was requested. The animals resurfaced 335 m to the airguns, after the power down occurred and then continued swimming away from the vessel up to a km away, 8 min after the power down. The three walruses were initially sighted within the 190 dB rms distance of 517 m to the 16 airguns, and also dove twice within this distance prior to the power down. All three were ***likely*** exposed to ≥190 dB rms.
- **Sighting #82:** Two gray whales entered the 1100 m safety radius, requiring a power down at 03:08 GMT on Aug. 29. The whales were first sighted at 02:57 GMT, breaching ahead of the vessel, 2500 m from the MMO. By 03:08 GMT they were within the safety radius, breaching 200 m from the MMO on the port side or 360 m from the 16 airguns, at which time the power down was requested. The whales remained outside of the 154 m shut down safety radius and were last seen at 03:10 GMT, 1800 m from the MMO, possibly lunge feeding. The two gray whales entered the 180 dB rms distance of 1628 m while underwater, so were ***very likely*** exposed to ≥180 dB rms. They also surfaced within the 190 dB rms distance of 517 m, so were also ***likely*** exposed to ≥190 dB rms before the power down occurred.
- **Sighting #85:** There was a power down requested on Aug. 30 at 04:21 GMT for a Pacific walrus. The animal was initially sighted ahead on the port side of the vessel, 207 m from the MMO or 442 m from the 16 airguns, requiring a power down. The animal came within 130 m from the observer before diving and not being seen again. The walrus was sighted within the 190 dB rms distance of 517 m, so was ***likely*** exposed to sounds ≥190 dB rms before surfacing.

- **Sighting #87:** At 16:30 GMT on Aug. 30, another power down was requested due to a Pacific walrus sighting. Two walruses were sighted ahead of the vessel, 150 m from the MMO or 436 m to the 16 operating airguns. The airguns were immediately powered down while the walruses stayed at the surface for 5 min, looking, swimming away from the vessel, and then diving. The walruses were sighted within the 190 dB rms distance, so were ***likely*** ensonified at ≥190 dB rms before surfacing.
- **Sighting #89:** A bearded seal sighted within the 500 m safety radius resulted in a power down on Aug. 30 at 20:46 GMT. The seal was looking and swimming ahead of the vessel, 192 m from the MMO or 476 m from the airguns. The 16 airguns were immediately powered down, at which time the seal swam away perpendicularly to the vessel until it was last sighted at 20:50 GMT. The bearded seal was sighted within the 190 dB rms distance of 517 m, so was ***likely*** exposed to ≥190 dB rms before it surfaced.
- **Sighting #97:** A power down interrupted a ramp up sequence at 00:33 GMT on Aug. 31 due to a sighting of an unidentified seal. A very small seal was sighted ahead and to starboard of the vessel, 178 m from the observer, at which time the power down was requested. The seal continued swimming vigorously until it was 100 m to the observer at which point it dove and was not seen again. The ramp up had been underway for only 4 min when the power down occurred, so <16 airguns were operating at the time of the sighting. The seal was initially sighted 418 m from the airguns and the 190 dB rms distance was <517 m, but it was still ***likely*** exposed to ≥190 dB rms before it surfaced.
- **Sighting #99:** On Aug. 31 at 01:23 GMT, an unidentified seal was sighted within the 500 m safety radius prompting a power down. The seal was swimming ahead and to port of the vessel when sighted, 225 m from the MMO or 456 m to the airguns, at which time a power down was requested. The animal continued swimming to within 150 m of the MMO before diving. A ramp up had been underway for 12 min when the power down occurred, so <16 airguns were firing. The seal was sighted within the 190 dB rms distance of ≤517 m, so was ***likely*** exposed to ≥190 dB rms before surfacing.
- **Sighting #105:** An unidentified seal sighting required a power down on Aug. 31 at 07:42 GMT. The small seal was sighted directly ahead of the vessel, swimming and then diving, 150 m from the MMO or 450 m to the airguns. A power down was requested as the animal was within the 500 m safety radius. Since the seal dove within the 190 dB rms distance of 517 m (for 16 airguns), it was ***likely*** ensonified at ≥190 dB rms.
- **Sighting #106:** Another power down was requested on Aug. 31 at 22:40 GMT. Two unidentified seals were sighted ahead of the vessel, 60 m from the MMO and 353 m to the airguns. The airguns were immediately powered down. The animals continued to swim to within 10 m of the MMO and were last seen 306 m from the MMO at 22:44 GMT. A ramp up was underway for 10 min at the time of the sighting, so <16 guns were operating when the power down occurred. The two seals were sighted within the 190 dB rms distance of ≤517 m, so were ***likely*** exposed to ≥190 dB rms before surfacing.
- **Sighting #107:** On Sept. 1 at 19:19 GMT, a power down occurred due to a Pacific walrus sighting. Two Pacific walruses were looking and swimming toward the airguns from ahead and to port, 178 m from the MMO and 418 m to the airguns. The 16 airguns were immediately powered down, and the walruses were last seen 250 m from the port side at 19:22 GMT when they dove. The two

walruses were sighted within the 190 dB rms distance of 517 m, so were ***likely*** both exposed to ≥190 dB rms before surfacing.

- **Sighting #108:** A power down was requested on Sept. 2 at 02:44 GMT for an unidentified seal sighting. The seal was first sighted 40 m from the MMO or 340 m to the airguns, directly ahead of the vessel. It front dove a couple times away from the vessel while the power down of the 16 airguns was being requested. The animal gradually veered of to port and was last seen 60 m away at 02:46 GMT. The unidentified seal dove within the 190 dB rms distance before the power down, so was ***likely*** exposed to sounds ≥190 dB rms.
- **Sighting #109:** A ringed seal sighting within the 500 m safety radius required a power down on Sept. 2 at 04:45 GMT. The seal was milling off the port side of the vessel, just 50 m from the MMO or 278 m to the airguns, at which time the 16 airguns were immediately powered down. The animal was last seen at 04:47 GMT. The ringed seal was first sighted within the 190 dB rms distance, so was ***likely*** ensonified at ≥190 dB rms before surfacing.
- **Sighting #110:** A power down occurred at 22:31 GMT on Sept. 4 due to an unidentified seal sighting. The seal was vigorously swimming across the bow, 50 m from the MMO and 350 m to the airguns, which were immediately powered down. The animal was last seen 60 m from the MMO, abeam on the starboard side of the vessel at 22:32 GMT. A ramp up had been underway for 4 min before this sighting, so <16 airguns were operating when the power down occurred. The seal was sighted within the 190 dB rms distance of <517 m, so it was still ***likely*** exposed to ≥190 dB rms before it surfaced.
- **Sighting #111:** On Sept. 10 at 04:58 GMT, a power down occurred for a ringed seal within the 500 m safety radius. The seal was looking at the vessel and swimming away from the vessel, 25 m from the MMO and 322 m to the 16 airguns. The airguns were immediately powered down after which the animal dove and was not seen again. The ringed seal was initially sighted within the 190 dB rms distance, so was ***likely*** exposed to sounds ≥190 dB rms before it surfaced.
- **Sighting #115:** A power down was requested for an unidentified seal on Sept. 15 at 23:28 GMT. The adult seal was sighted ahead and to starboard, 150 m from the MMO or 397 m from the 16 airguns. The airguns were powered down while the animal looked at the vessel, swam away and then dove. The unidentified seal was sighted within the 190 dB rms distance, making it ***likely*** that it was ensonified at ≥190 dB rms before surfacing and being initially sighted.
- **Sighting #119:** Two pacific walruses were sighted within the 500 m safety radius, necessitating a power down on Sept. 22 at 03:59 GMT. The walruses were sighted ahead and to port, 200 m from the MMO and 436 m to the 16 operating airguns. While the power down was being requested, the animals looked and swam parallel to the vessel, then dove and were not seen again. The two walruses were sighted within the 190 dB rms distance of 517 m for the full array, so were ***likely*** exposed to sounds ≥190 dB rms before surfacing.
- **Sighting #120:** On Sept. 23 at 16:36 GMT, a power down occurred due to an unidentified seal sighting. The seal was ahead and to port, swimming away from the vessel, 40 m from the observer and 322 m to the 16 operating airguns. The animal was only at the surface for 10-15 sec, before the power down was requested. Since the seal dove within the 190 dB rms distance of 517 m before the power down occurred, it was ***very likely*** ensonified at ≥190 dB rms.

- **Sighting #124:** A power down was requested on Sept. 24 at 17:31 GMT. It occurred because an unidentified seal was sighted ahead of the vessel, 306 m from the MMO and 585 m to the airguns. The 16 airguns were powered down since the seal was swimming toward the airguns and was about to enter the 500 m safety radius. The seal submerged when it was 30 m from the port side of the vessel. Since the seal did not enter the 190 dB rms distance of 517 m before the power down occurred, it was ***unlikely*** exposed to sounds ≥190 dB rms.
- **Sighting #127:** An unidentified seal was sighted within the 500 m safety radius, causing a power down at 18:31 GMT on Sept. 24. The seal was swimming away from the vessel, 50 m directly ahead of the MMO and 350 m to the airguns. It was only on the surface for a few seconds though, submerging before the power down was enacted. A ramp up had been underway for 20 min (out of a 21 min ramp up sequence), so it is likely that 16 airguns were firing at the time of this sighting. The seal dove within the 190 dB rms distance of 517 m before the power down occurred, making it ***likely*** that it was exposed to ≥190 dB rms.
- **Sighting #135:** On Sept. 25 at 01:36 GMT, a power down occurred due to an unidentified seal sighting. The seal was initially sighted directly ahead of the vessel at 01:32 GMT, 584 m from the MMO and 884 m from the airguns. The animal dove and was re-sighted at 01:36 GMT, 200 m from the MMO and 400 m from the airguns, at which time a power down of the 16 operating airguns was requested. The seal surfaced within the 190 dB rms distance of 517 m, so was ***likely*** ensonified at ≥190 dB rms.
- **Sighting #136:** A Pacific walrus sighting necessitated a power down on Sept. 25 at 02:14 GMT. The tuskless walrus was ahead and to port, 273 m from the MMO and 496 m to the airguns. It was swimming and then dove toward the airguns while the power down was being requested. A ramp up sequence had been underway for 8 min, so <16 guns were firing before the power down. The walrus dove within the 190 dB rms distance of ≤517 m, so was ***likely*** briefly exposed to ≥190 dB rms before the power down occurred.
- **Sighting #137:** Another Pacific walrus sighting resulted in a power down on Sept. 25 at 03:32 GMT. This walrus was first sighted ahead of the vessel at 03:25 GMT, at a distance of 347 m from the MMO, outside the 500 m safety radius around the airguns. The animal was lying on its back, logging then swimming sedately at the surface. By 03:32 GMT, the animal had swum into the safety radius and was 200 m from the observer or 484 m to the 16 operating airguns, at which time a power down was requested. The walrus was last seen at 03:36 GMT. The walrus was initially sighted outside the 190 dB rms distance of 517 m, so it was ***unlikely*** exposed to ≥190 dB rms before surfacing.
- **Sighting #139:** On Sept. 28 at 17:47 GMT, a power down occurred due to a Pacific walrus sighting within the 500 m safety radius. The walrus was sighted at 17:44 GMT, ahead of the vessel, 80 m from the MMO and 371 m to the airguns. The animal popped out of the water and looked at the vessel, dove, surfaced, looked, swam, dove, and was not seen again. The sighting occurred a few minutes before the end of the line, so once the power down request was made, the 16 airguns were already being powered down because it was the end of the line at 17:47 GMT. The walrus dove within the 190 dB rms distance of 517 m before the power down was enacted, so the animal was ***likely*** exposed to ≥190 dB rms.
- **Sighting #140:** There was a power down requested on Sept. 29 at 17:15 GMT for an unidentified seal. It surfaced 30 m from the MMO or 330 m from the airguns, swam away from the vessel a bit

and then dove. The airguns were powered down from 16 operating airguns to one operating mitigation gun. The seal dove within the 190 dB rms distance of 517 m before the power down occurred, so was ***very likely*** briefly exposed to ≥190 dB rms.

- **Sighting #141**: Another unidentified seal sighting required a power down at 17:55 GMT on Sept. 29. The seal surfaced directly ahead of the vessel, 20 m from the MMO or 320 m from the airguns, stayed at the surface for 30 sec and then dove. The airguns were powered down from 16 operating airguns. Since the seal dove within the 190 dB rms distance before the power down could occur, it was likely briefly exposed to ≥190 dB rms.
- **Sighting #142:** On Sept. 29, a third power down occurred for an unidentified seal at 18:20 GMT. This seal was sighted ahead and to port, 15 m from the observer and 315 m from the airguns, swimming away from the vessel for 45 sec before diving. The 16 airguns were powered down, but it is still ***likely*** that the animal was briefly ensonified at ≥190 dB rms.
- **Sighting #145:** A fourth power down for an unidentified seal was requested at 18:41 GMT on Sept. 29. The seal was initially sighted outside of the 500 m safety radius, swimming away from the vessel, 347 m from the MMO or 647 m from the 16 operating airguns. The airguns were immediately powered down since the seal was near the safety radius. The seal dove and was not seen again. Since the seal did not enter the 190 dB rms distance of 517 m before the power down occurred, it was ***unlikely*** exposed to sounds ≥190 dB rms.

# APPENDIX I:

## MARINE MAMMAL DENSITY ESTIMATES

TABLE I.1. Expected densities of marine mammals in offshore areas of the Alaskan Chukchi Sea (see Chapter 4 for more details). Densities are corrected for $f(0)$ and $g(0)$ biases (see Appendix E). $F(0)$ values, derived from the study's sightings are included.

| Species | Density - Seismic (No. individuals /1000 km$^2$) | Density - Non-seismic (No. individuals /1000 km$^2$) | $f(0)$ (sightability) correction factor |
|---|---|---|---|
| **Cetaceans** | | | |
| Unidentified Whale | N/A | 0.0005 | 0.73 |
| **Odontocetes** | | | |
| Unidentified Dolphin | N/A | 0.0005 | 0.87 |
| Beluga Whale | N/A | N/A | N/A |
| Harbor Porpoise | N/A | 0.0014 | 1.63 |
| Killer Whale | N/A | N/A | N/A |
| **Mysticetes** | | | |
| Unidentified Mysticete Whale | N/A | N/A | |
| Bowhead Whale | 0.0005 | 0.0018 | 1.25 |
| Fin Whale | N/A | N/A | |
| Gray Whale | N/A | 0.0015 | 1.12 |
| Minke Whale | N/A | N/A | N/A |
| **Pinnipeds** | | | |
| Unidentified Pinniped | 0.0033 | 0.0005 | 2.45 |
| **Odobenids** | | | |
| Pacific Walrus | 0.0051 | 0.0121 | 1.73 |
| **Phocids** | | | |
| Unidentified Seal | 0.0301 | 0.0813 | 3.61 |
| Bearded Seal | 0.0091 | 0.0323 | 4.92 |
| Ribbon Seal | N/A | N/A | N/A |
| Ringed Seal | 0.0094 | 0.2851 | 6.34 |
| Spotted Seal | 0.0071 | 0.0278 | 5.47 |